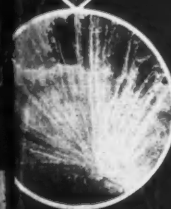


# CHEMISTRY



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## Planets Are Not Electrons

► THE AMAZING advance of science in the first half of this century is nowhere better illustrated than in the present-day use of isotopes. Fifty years ago the atomic weight of an element was believed to be its most constant property, and the possibility of tracing the course of a single atom would have seemed forever impossible. Today one element may have many atomic weights, while the path of a single radioactive atom may be traced quite easily through a series of complex reactions. With so many new and apparently contradictory ideas, the legend has gotten about that nothing is impossible now, and that therefore everything is to be believed—the more fantastic the better.

A current attack on science takes as its text a statement in the Book of Joshua that the sun and the moon stood still while the conquering Israelites massacred an enemy tribe. The statement is usually construed to mean that the slaughter was done quickly, for it is described as only one episode in a long and bloody series of conquests. In the new interpretation, the earth is supposed to have stopped rotating, accompanied by jumps in the orbits of the planets Mars and Venus. This strange planetary behavior is apparently borrowed from chemistry. The author of the theory mistakes a figure of speech referring to a change in energy level for authority to set members of our solar system loose on a lawless joy-ride. Whether this is well-intentioned ignorance or deliberate hoax, it differs fundamentally from the scientific method.

Data gathered from scientific study, in common with all records of human achievement, must join together to form a self-supporting network of consistent truth.

When such a check would interpolate into recorded history events that would have fused the entire surface of our planet and blown any loose cinders into the next galaxy, it is far simpler to assume that ancient chroniclers used poetic license. Even electrons jump their orbits only according to the laws of quantum mechanics.

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### CHEMISTRY

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► *RADIOACTIVE MATERIAL is withdrawn from the atomic pile at Oak Ridge, Tenn., by a team of workers including the omnipresent man with the Geiger counter. The menace of radiation injury is always near those who prepare radio-isotopes for research, and Oak Ridge is justly proud of its safety record.*

## Isotopes to Order

by HELEN M. DAVIS

► IN ITS FIRST three years of operation, America's strangest industry, the isotope shipping center at Oak Ridge, Tenn., not only doubled and redoubled its output but outgrew completely its original makeshift quarters. Isotopes processed from nuclear fission products find constantly increasing markets in research laboratories. More demands keep pouring in for the most useful of the tell-tale atoms which Oak Ridge can supply. More stocks of isotope solutions have to be kept on hand to fill the orders.

At first such solutions could be stacked up in out-of-the-way corners and walled off with lead brick. It was not long until this procedure led to an embarrassing shortage of lead brick. Stocks which had to wait a long time for their "hot" components to decay to manageable levels of activity were buried in the ground. It became more evident every day, as the isotope

business increased, that a center for the storage, packing and shipping of isotopes would have to be created.

Accordingly the Carbide and Carbon Chemicals Division of Union Carbide and Carbon Corporation, who now operate the Oak Ridge National Laboratory, have built and put into operation a special plant where isotopes can be stored and packed. These isotopes are separated from the mixed lot of radioactive products that result from operation of the nuclear reaction pile. They are in demand by research laboratories because they trace the course of individual atoms through life processes or other obscure chemical reactions.

More than 700 research projects using radioisotopes to promote health and cut industrial waste in the United States and 21 other countries are expected to profit from improved isotope shipping facilities just opened at the Oak Ridge, Tenn., National Laboratory.

MARCH, 1950

CHEMISTRY HALL LIBRARY 1



➤ AUTOMATIC TONGS can lift any bottle selected by the operator on the other side of the concrete barrier and carry it to the packing area. Isotopes are supplied to users in hydrochloric acid solution, as the handiest form for conversion to whatever compound the user wishes. For purposes of display, before the new center was actually put into use, bottles were filled with a non-radioactive dye solution so that they would show up in the pictures.



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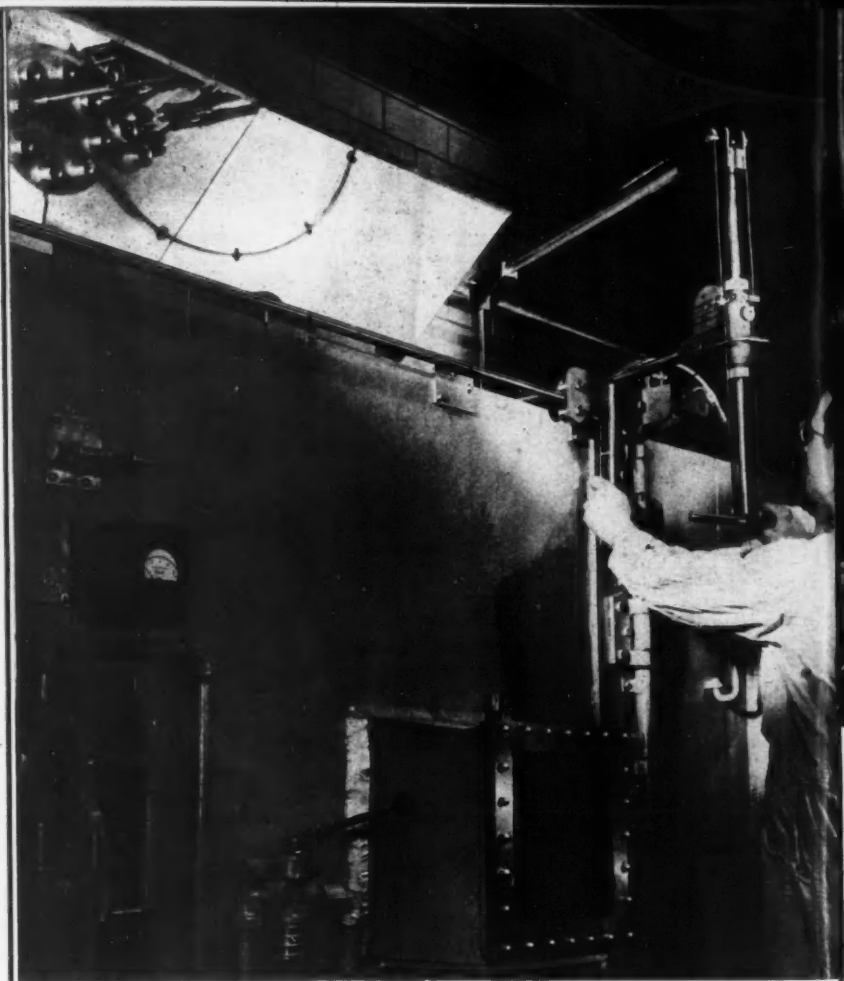


► SAFETY BARRICADE, behind which bottles of radio-isotope solutions are racked, is a two-foot-thick concrete wall. The travelling crane with long-distance tongs lifts any bottle the operator selects and carries it to the packing area, which is shown in the picture, at right angles to the barricade. Overhead mirrors and a periscope on the crane allow the operator to watch every motion. The men claim it soon becomes more natural for them to work looking in mirrors than watching directly.

New buildings where dangerously radioactive fission products from the atomic pile can be stored behind adequate shielding walls and handled with production-line methods by remote control have just been put into service by Carbide, operating the plant for the Atomic Energy Commission. At the same time the Commission announced a reduction in the prices of isotopes which result from uranium fission, and stated that these radioactive materials will now be available in increased quantities.

Mirrors and periscopes in the new packing area allow the men who handle radioactive fission products to see the bottles they pick up. They work with long-distance tongs manipulated by means of levers and steering wheels.

With these a measured quantity of radioactive liquid can be taken out of a stock bottle and transferred to the bottle in which it is to be shipped. Caps can be screwed back on the bottles, the measuring pipette washed, the stock bottle returned to its



► THE CORNER of the packing area in the new isotope plant at Oak Ridge, Tenn., is cleverly utilized. A pipette holder, adapted to long-distance manipulation, travels around a circular track in this space. It is used to transfer a measured quantity of isotope solution from the stock bottle to the smaller bottle in which shipment will be made. The picture shows, in the overhead mirror, the crane and stock bottle on the right and, on the left, a shipping bottle, in one of the eight compartments of its rack, being filled from a pipette.

Ridge,  
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transfer a  
smaller  
overhead  
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pipette.

CHEMISTRY

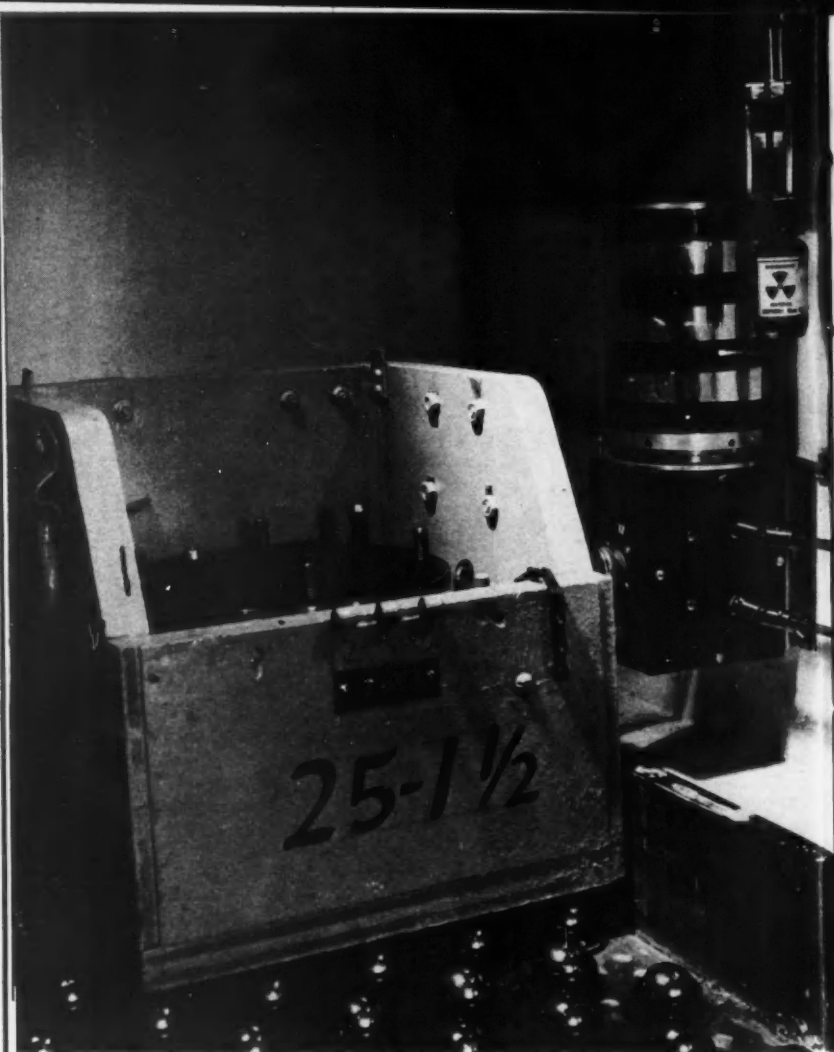


► TESTING for radioactivity leaks on all six surfaces of every shipping container makes sure that no radiation escapes while the isotope solution is in transit. Photographic film may rest safely beside such a container in a box car with no danger of being fogged. The weight of the whole shipment, with its lead shielding, is on the order of a billion times that of the radioactive content of the solution so protected.

numbered place and the smaller bottle placed in its shielded shipping container, all by a man separated by a two-foot-thick concrete wall from the glassware he is handling.

Priced according to its rating in millicuries of radioactivity, a radioisotope is shipped usually in hydrochloric acid solution, looking like a small medicine bottle full of water.

No hint of the powerful rays emanating from this harmless-looking solution reaches the senses, but Geiger counters and other detecting apparatus, mostly of Oak Ridge manufacture, monitor every outgoing package. Packing material to shut out radiation, and also to soak up the liquid in case the glass should break, surrounds the bottle if the contents are



► SHIPPING CONTAINER, made of lead and housed in a heavy wooden box, is ready to receive the bottle of isotope solution being carried by the tongs. Note the radioactivity symbol on the label, three segments of a circle printed in "shocking pink" (approximately the color of this month's cover of CHEMISTRY).

not too dangerous. The whole package is then canned in a commercial tin can of the size often used for tomato juice.

More violently radioactive materials require foot-thick walls of lead to prevent their dangerous rays from leaking through. A few hundredths of a gram of active material may have a shipping weight of many pounds by the time its protective containers are assembled.

Research on cancer is carried on by means of two especially important isotopes from the Oak Ridge atomic pile. Iodine 131, which concentrates

in the thyroid gland, and phosphorus 32, which is picked up by bone marrow and other specialized tissues, are most in demand by research groups. Phosphorus 32 has a long life and may be stock-piled for a considerable time, but isotope production at the atomic pile is geared to the short half-life of the iodine isotope. Taken from the reactor on Monday, it is stored long enough for accompanying unwanted radiation to die away, then packaged, and on Friday of each week loaded on the plane for delivery to research centers where it will take up its experimental role the following week.

### *On the Back Cover*

► RADIOACTIVE ISOTOPES, usually in hydrochloric acid solution, are stored in these stock bottles behind an insulating wall of concrete, in the new isotope shipping center at Oak Ridge, Tenn. Storage areas are apportioned to isotope solutions in order of their radioactivity, those giving off the most dangerous radiations are kept at the end of the 40-ft. compartment farthest from the operator who measures and packs the solutions for shipment. Letter and number codes, painted in reverse since they have to be read in the mirror, enable the operator to select any solution by means of the indirect tongs designed for handling these hazardous materials.

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## Isotope Separation Plants Never Before Contemplated

# How Oak Ridge Operates

*From Office of Oak Ridge Operations, A. E. C.*

► THE GASEOUS diffusion plant for the concentration of U-235 lies in Roane County in the southwest corner of the area near the Clinch River, approximately 13 miles from the town of Oak Ridge. Design work on this plant was started early in 1943 by the Kellogg Corporation, a unit of the M. W. Kellogg Corporation of New York City, which also handled the supervision of construction and procurement of equipment. Chief construction contractor was the J. A. Jones Construction Company of Charlotte, North Carolina, while Ford, Bacon & Davis, Inc. of New York, designed, constructed and for a time operated an auxiliary 400 x 1000-foot plant to condition equipment before placement in the process plant.

The gaseous diffusion plant is operated by the Carbide and Carbon Chemicals Division, Union Carbide and Carbon Corporation, which signed a contract January 20, 1943, for its operation. Carbide, which also made important contributions to the planning and research and construction of the facility, operated in Oak Ridge up to January 1, 1950, as the Carbide and Carbon Chemicals Corporation.

The main gaseous diffusion process building, K-25, is a huge U-shaped structure. Each side of the building is 2,450 feet long and averages 400 feet in width and 60 feet in height. The

total area of the main building is 44 acres. Nearby is a second gaseous diffusion process building, K-27, approximately one-fourth as large as the main process building. The plant area contains 70 additional buildings, bringing the total area to 600 acres. Besides the conditioning building, the plant has a repair shop and special warehouses containing tens of thousands of different types of spare parts.

Two other gaseous diffusion units, K-29, costing \$66,000,000 and K-31, costing \$162,000,000 are being built.

Construction of the main process plant started September 10, 1943, and the first units for the production of U-235 began operating February 20, 1945. The Construction forces on this particular plant reached 25,000 in May, 1945. The peak operating force for this process was around 12,000. Employment as of January 1, 1950, was around 4,000. The gaseous diffusion plant cost around \$500,000,000, exclusive of new units now being built.

The vast structure and its process equipment has been described as a monument to the ingenuity and vision of America's top scientists and development engineers, headed by Dr. Harold C. Urey, the discoverer of "heavy water" and Dr. John R. Dunning, both of Columbia University and P. C. Keith of the Kellogg Corporation. The immensity of the proj-

ect of constructing the gaseous diffusion plant is evidenced by some of the statistics of the quantities of materials required. These materials were: concrete, 350,000 cubic yards; structural steel, 40,000 tons; sheet steel, 15,000 tons; and bricks, 5,000,000.

The purpose of the gaseous diffusion plant is large-scale separation of the uranium isotope 235 from a chemical compound of uranium by gaseous diffusion through porous barriers — barriers which must contain billions of holes smaller than two-millionths of an inch, withstand a pressure head of 15 pounds per square inch, can not become enlarged or plugged up as a result of corrosion or dust coming from elsewhere in the system, amenable to manufacture in large quantities (measured in acres) and in uniform quality. The process involves several thousand stages in which half of the gas processed in each stage diffuses through the porous barriers as enriched U-235 product and is then sent on to the next higher stage for further concentration. The impoverished half is re-pressured and re-cycled through the next lowest stage. The volume of gas re-cycled is enormous —over 1,000,000 times the volume of the enriched gas. The principal behind the separation of U-235 from natural uranium (U-238) is to convert the solid metal into a gas and make use of the difference in the velocity of the two isotopes in diffusing through the porous barriers. Being the lighter, U-235 has a faster diffusion velocity, so the gas eventually diffused through the barrier is richer in U-235 than the feed gas. After passing through the several thousand

stages, an appreciable concentration of U-235 is effected.

No similar plant had ever before been contemplated, much less built. Essential tolerances and complexities were such that many advisors considered the plant impossible to build, and many more felt that even if built it would not work. Problems were encountered that called for excursion far into the unknown beyond any known method of design and construction. Development of some of the materials and equipment used in the plant was not successfully completed until after construction was well under way. The equipment required the installation of many miles of piping and electrical conductors. So important was the problem of producing welded joints to meet tightness and cleanliness specifications that it was necessary to develop 14 new special welding techniques. Installation of piping for the main process building exceeds anything of this type ever before constructed. Millions of feet of copper tubing were installed in the instrument system. The successful operation of the plant is dependent to a large extent upon the reliability of the instruments.

In connection with new techniques needed for the operation of the plant, pumps were developed to operate at velocities greater than the speed of sound. It has been estimated that the time spent in research, development and the design of the pumps alone total 250,000 hours or the equivalent of one engineer working 100 years. Other technical advancements made in the development work on the plant include a new improved type of mass

spectroscope and an electronic gadget called the "leak detector," which has a sensitivity far in excess of any current apparatus and plays an important part in insuring that all parts of the gaseous diffusion plant are vacuum tight. Industry in time will reap rich rewards from technical advancements made in these and other fields.

### Electromagnetic Plant

The electromagnetic plant for the concentration of U-235, production of stable isotopes and research on process improvements, is situated in Anderson County near the center of the Oak Ridge Area approximately three miles from the town of Oak Ridge. The Stone & Webster Engineering Corporation of Boston designed and constructed the plant in cooperation with technical experts from the University of California. The cost was approximately \$427,000,000. The ground was broken for the first plant building February 1, 1943. The first production building was put into use by the operating company, the Tennessee Eastman Corporation (a subsidiary of Eastman Kodak) on January 27, 1944.

The peak of plant construction employment totaled 13,200 workers. The peak of operational personnel was 22,000 in 1945. Employment at the electromagnetic plant on January 1, 1950, was approximately 1600. The plant has a total of 170 buildings with a floor area of 4,500,000 square feet. The plant covers approximately 500 acres. On May 5, 1947, the plant operations were taken over by Carbide and Carbon Chemicals Division, Union Carbide and Carbon Corporation, after the Tennessee Eastman

Corporation evinced a desire to withdraw as operator.

The building of the electromagnetic plant involved problems of design and construction never before encountered. Since it became the first and only plant of its kind in the world, there was no time to construct even a small pilot plant to carry out the methods of separating the uranium atoms, U-235 from U-238, under the electromagnetic process. This was developed by Dr. E. O. Lawrence of the University of California, who receives the largest share of credit for the scientific development which made possible the remarkable transmutation from the laboratory into a great industrial plant.

While the Stone & Webster Engineering Corporation was selected to design and build the plant, General Electric, Westinghouse and Allis-Chalmers were the manufacturers and suppliers of the equipment. The electromagnetic process used an enormous amount of electric power and this was a compelling reason for its location in the Tennessee Valley.

The following quantities will give some indication of the size of the construction phases of the electromagnetic process: excavation — 1,000,000 cubic yards; concrete — 275,000 cubic yards (the buildings themselves are not concrete); and lumber—37,562,000 FBM.

Basically, the theoretical operation of the electromagnetic type of plant involves ionizing chemically-treated uranium particles, accelerating a continuous stream of these particles in a closely-defined path to a speed approaching that of light, bending this stream into semi-circles by means of



a powerful magnet field in an almost absolute vacuum, and then catching the particles of U-235 and U-238 in different containers as soon as they become separated. The semi-circular paths of these ionized particles will have radii proportional to their momenta. Accordingly, the U-235 is mainly in an arc which has a greater radius than the arc containing U-238.

The electromagnetic plant was flexible — one reason for its selection. Units were built in groups, although most of the controls were separate from each unit. Thus, it was possible to build the plant in steps and to start operating the first unit before the second was begun. Design of subsequent units was changed as construction proceeded and obsolescent units were replaced, insuring smoother plant operation and increased output. So successful was this program that obsolescent equipment was replaced rapidly by new designs, which ultimately resulted in such an improvement in process that it was possible to carry on operations with much less personnel than the peak operating forces of 22,000 employees.

In the development of the plant, pumping equipment was designed and built capable of producing a vacuum 30,000,000 times that commonly used in standard power plant practice.

Magnets were designed and built containing thousands of tons of steel each; nearly 100 times as large as any previous magnets ever built. They were 250 feet long, so powerful that their pull on the nails in the heels of a pair of shoes made walking difficult and a wrench might be snatched from

a workman's hands. Complete kits of non-magnetic tools were designed and manufactured. The flying ionized particles could have sliced through ordinary metals, so elaborate shield-protectors of exacting machined carbon were designed and fabricated. During construction, copper was scarce and time was more valuable than gold, so approximately 14,000 tons of silver was borrowed from the U. S. Treasury for use as conductors. The Commission is now acting as custodian for the Treasury Department for this silver.

The U-235 produced in the electromagnetic plant during the war was so precious that Stone & Webster designed a chemical salvage plant 100 times as large as any test plants that could be used as guides. Every possible grain of U-235 was reclaimed — from work clothes, from water and steel, and even in the air in the plants. And all of the operating units had to be run by amazingly automatic controls by personnel of average intelligence (many of the employees were high school girls), who had not the faintest idea what their jobs were about, but operated dials to produce the material which, when used, liberated a part of the power of the universe.

Some 6,200,000 linear feet of piping were required for the plant buildings. This included water lines, oil lines for cooling purposes, chemical lines and vacuum piping. Altogether, nearly one quarter of a million valves were installed. Cleanliness was essential for successful operation of the process and this necessitated construction of a special pickling and washing plant for cleaning pipes and valves. Each

section of pipe and each valve was carefully sealed after treatment. A seal could not be broken until just before assembling the line.

### **Nuclear Research Center**

Oak Ridge National Laboratory is situated in Roane County near Clinch River in the southeast part of the area, about 12 miles from the city of Oak Ridge. The plant was designed and built by E. I. duPont de Nemours and Company. It was originally a small pilot plant on which the design of the huge Plutonium plant at Hanford Engineer Works in the State of Washington was based. Construction began February 1, 1943, and operations of the first uranium chain-reactor in the world with a production potential began at 5 a.m. November 4, 1943. First significant amounts of plutonium for research leading to the building of the Hanford Plant were obtained here. The plant cost approximately \$13,000,000 and peak construction reached 3,247 employees. Peak operating employment in wartime was 1,234. Employment on January 1, 1950, was around 2,000.

Until July 1, 1945, the plant was supervised by the University of Chicago. It was then taken over by the Monsanto Chemical Company of St. Louis for operation as a nuclear research center. On December 31, 1947, the Atomic Energy Commission announced the Carbide and Carbon Chemicals Division, Union Carbide and Carbon Corporation, would operate the Laboratory beginning March 1, 1948. On February 1, 1948, the Atomic Energy Commission announced that the new name for the facility would be Oak Ridge National

Laboratory. It was formerly known as Clinton Laboratories.

This area contains more than 150 buildings. These include three chemistry buildings, a technical laboratory, a pile building (a pile of specially designed graphite into which slugs of U-238 are placed), a physics laboratory, a power house, an electronic instrument development building, machine shop and research development shops, a lead shop, a medical building (headquarters for the Health Physics group which controls and studies radiation hazards) and several administration buildings and warehouses.

In keeping with its designation as a permanent National Laboratory, the Laboratory is being enlarged and modernized under a \$20,000,000 expansion program.

The pile at Oak Ridge National Laboratory is the source of production and distribution of radioactive isotopes which are now being widely used for research in medicine, biology, agriculture and industry. Since August 2, 1946, many hundreds of shipments (over 9,000 as of January 1, 1950) have gone to various research groups in the United States and in more than two-score foreign nations. The distribution of these radioisotopes is one of the most important peacetime applications of the development of atomic energy.

Other peacetime work being carried on at Oak Ridge National Laboratory in nuclear research includes studies in tracer chemistry; biological research; a health physics program and basic research and chemical process development work at the Laboratory.

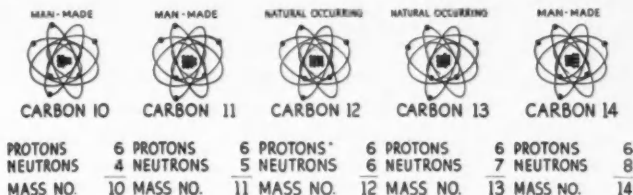
# WHAT AN *Isotope* IS ....

HYDROGEN ATOMS CAN  
HAVE SEVERAL FORMS

THESE ARE  
ISOTOPES



## Another FAMILY of ATOMS WHICH ARE ISOTOPES



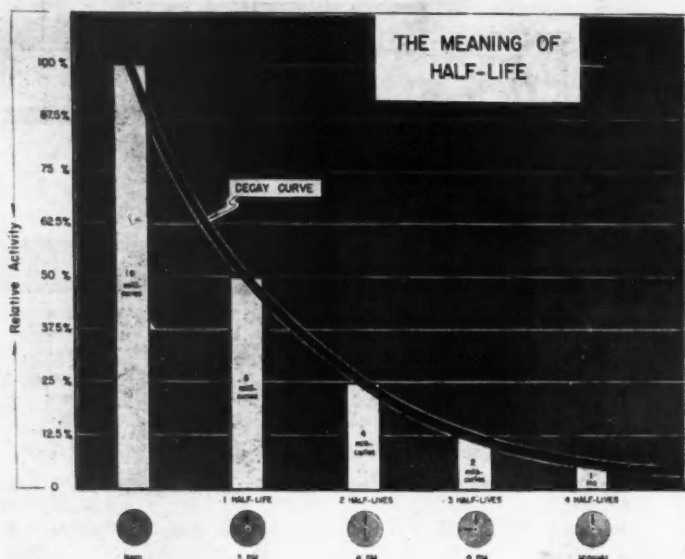
► CHARTS which the Atomic Energy Commission has prepared to explain the nature of isotopes and their usefulness in research are reproduced here in miniature.

Isotopes, says the Commission, in a publication summarizing its three years of isotope distribution, are particularly valuable as tracer atoms.

By using isotopic tracers, atoms of elements can often be traced in minute quantities—thousands to millions of times smaller than those detectable by chemical means. More important even than this sensitivity is the specificity of the method. A specific batch of atoms or molecules may be labelled uniquely and traced through a series of chemical or physical reactions. They can be traced independently even in the presence of other atoms or molecules of

the same substance, and in spite of multiple reactions with numerous other kinds of atoms and molecules. This permits the ferreting out and untangling of complicated processes that often can be followed in no other way. Radioactive isotopes have also proved useful in certain therapeutic and industrial applications in which they are used as sources of ionizing radiation.

Isotopes for scientific research are manufactured in three ways. The *nuclear reactor* produces the great bulk of the radioisotopes distributed; it is the reactor that has made possible today's tremendous development of isotopic research. Some radioisotopes, however, still can be produced only in *cyclotrons*, as they were before the advent of the reactor, at far greater ex-



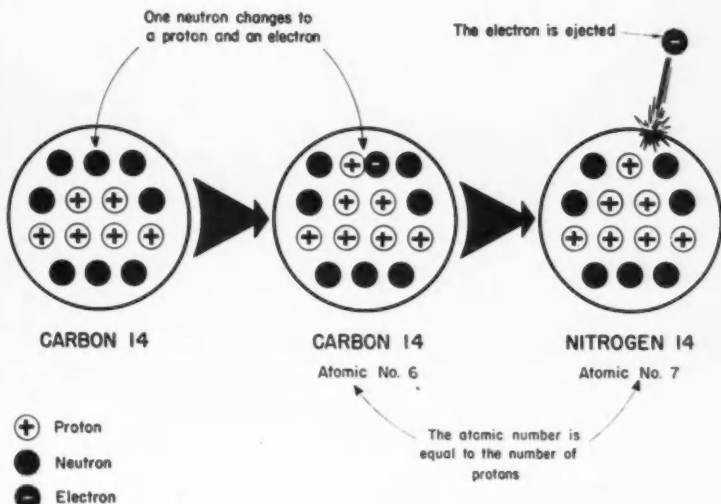
► THE CHART shows the rate of radioactivity decay of an isotope having a 3-hour half-life, such as cesium 134. Every radioisotope is characterized by its own half-life. Half-lives range from  $10^{-10}$  seconds for antimony 121 to  $10^{10}$  years for lutecium 176. The above graph (with a different time scale) applies to the decay of any isotope.

pense and in much smaller quantities. Stable isotopes, which are also useful in research, are not created by man but are separated from the chemical elements of which they are a natural part. Most of them are produced by *electromagnetic separation* in the huge machines that were built during the war to separate fissionable uranium 235 from natural uranium. During the last year the Commission has taken important steps to improve further the supply of all these kinds of isotopes.

A recent improvement in Oak Ridge facilities has made it possible to handle irradiated samples containing a greater amount of radioactivity than in the past. Previously it was necessary to limit the amount of material irradiated in one unit to prevent injury to the workers who withdrew samples from the reactor. Newly designed protective equipment has removed this limitation. In consequence, not only may users now receive shipments of isotopes containing larger quantities of

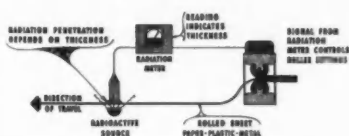
(Please turn to page 18)

# RADIOACTIVITY OF CARBON 14



Unstable Carbon 14 decays radioactively to form Nitrogen 14. One of the neutrons in the nucleus changes to a proton and an electron, creating a nucleus of seven protons and seven neutrons. At the same time, one electron is emitted from the nucleus at a high speed with about 145,000 electron-volts of energy. The new nucleus is now stable. Seven orbital electrons (not shown) group around it, and the new atom is Nitrogen 14. Half of any large group of Carbon 14 atoms will decay in this manner in 5,000 years, half of the remaining Carbon 14 atoms in another 5,000 years, etc. (For clarity, the protons and neutrons in the nuclei are shown in neat array on the above diagram. Actually, they are completely mixed together and in a constant state of motion.)

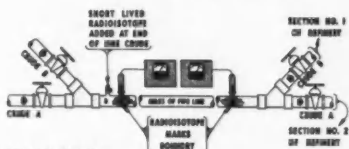
## RADIOACTIVE SOURCE FOR GAGING THICKNESS



### ADVANTAGES:

- 1- RADIATION SOURCE SELECTED TO SPLIT MATERIAL
- 2- NO CONTACT - NO TEASING - NO MARKING MATERIAL
- 3- RAPID AND RELIABLE

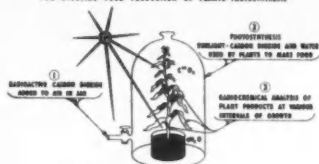
## RADIOACTIVE ISOTOPES FOR TRACING OIL FLOW IN PIPE LINES



### ADVANTAGES:

- 1- RADIOACTIVE "MARKER" CAN BE TRACED OVER LONG DISTANCE
- 2- "MARKER" SPREADS TO ONLY SMALL OIL VOLUME
- 3- PERMITS SEPARATION OF CRACKS WITH MINIMUM OF LOSS
- 4- METHOD QUICK AND REQUIRES NO SAMPLING

### RADIOACTIVE CARBON - $C^{14}$ FOR STUDYING FOOD PRODUCTION BY PLANTS - PHOTOSYNTHESIS



#### SHOWS:

- 1- RAPIDITY OF LIFE PROCESSES
- 2- INTERMEDIATE STAGE IN PRODUCING FOODS
- 3- ROLE OF CHLOROPHYLL (GREEN PRINCIPLE)

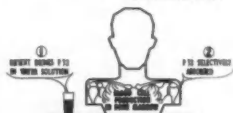
### RADIOACTIVE SODIUM - $Na^{24}$ FOR DETECTING NORMAL AND RESTRICTED BLOOD CIRCULATION



#### ADVANTAGES:

- 1- GIVES PATTERN OF BLOOD FLOW
- 2- PERMITS EXACT LOCATION OF ARTERIAL CONSTRICTION
- 3- METHOD QUICK AND NO DISCOMFORT TO PATIENT

### RADIOACTIVE PHOSPHORUS - $P^{32}$ FOR TREATMENT OF: A- POLYCYTHEMIA VERA B- CHRONIC LEUKEMIA



#### THERAPEUTIC ACTION:

- 1- PARTIALLY SELECTIVE UPTAKE
- 2- SLOW PROTRACTED IRRADIATION
- 3- INHIBITS BLOOD CELL PRODUCTION

### RADIOACTIVE PHOSPHORUS - $P^{32}$ FOR STUDY OF PHOSPHATE FERTILIZER UPTAKE



#### SHOWS:

- 1- FIXATION OF PHOSPHORUS OF SOIL
- 2- PHOSPHORUS UPTAKE BY PLANT
- 3- PROPER TIME AND PLACEMENT OF FERTILIZER
- 4- EFFICIENCY OF FERTILIZER

### RADIOACTIVE CARBON - $C^{14}$ FOR STUDYING CANCER PRODUCING AGENTS - CARCINOGENS



#### SHOWS:

- 1- AMOUNT OF AGENT IN CANCER AND OTHER TISSUE
- 2- LOCATION OF BREAKDOWN PRODUCTS OF THE AGENT
- 3- MODE OF ACTION OF CANCER PRODUCING AGENT

### RADIOACTIVE SODIUM - $Na^{24}$ FOR STUDYING SODIUM TURNOVER IN BODY



#### SHOWS:

- 1- RATES OF SODIUM TRANSFER THRU BLOOD VESSEL WALLS
- 1- FAST - TO TISSUE FLUIDS - 80% SALT PER DAY TO SWEAT IN 70 SECONDS
- 2- MEDIUM - TO FLUID OF EYE-BRAIN-SPINAL CORD
- 3- SLOW - TO BONES AND TEETH

### RADIOACTIVE PHOSPHORUS - $P^{32}$ FOR LOCATING EXTENT OF BRAIN TUMORS



#### ADVANTAGES:

- 1- ABSORPTION GREATER (3-100 TIMES) IN TUMOR THAN NORMAL BRAIN TISSUE
- 2- LIMITS OF TUMOR MASS ACCURATELY DETERMINED
- 3- METHOD CAN BE USED DURING SURGERY

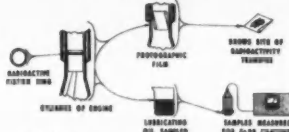
### RADIOACTIVE CALCIUM - $Ca^{45}$ FOR STUDYING PLANT NUTRITION



#### INDICATES:

- 1- ROOTS SUPPLY INSUFFICIENT CALCIUM FOR PROPER GROWTH
- 2- LOCATION OF MAXIMUM ABSORPTION
- 3- ABSORPTION DURING EARLY PLANT GROWTH

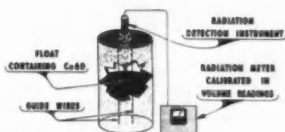
### RADIOACTIVE IRON - $Fe^{59}$ FOR FRICTION AND LUBRICATION STUDIES



#### ADVANTAGES

- 1-TRANSFER OF IRON REPRODUCED TO PHOTOGRAPHIC FILM
- 2-IRON SAMPLED DURING OPERATION OF ROTOR
- 3-DEVELOPED FILM SHOWS LOCATION OF WEAR

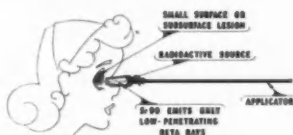
### RADIOACTIVE COBALT - $Co^{60}$ FOR LIQUID LEVEL GAGE



#### ADVANTAGES:

- 1-CONTINUOUS RECORDING
- 2-MEASUREMENT MADE ON CLOSED SYSTEM
- 3-ADAPTABLE TO AUTOMATIC CONTROL

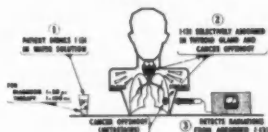
### RADIOACTIVE STRONTIUM - $Sr^{90}$ FOR TREATING SMALL LESIONS



#### ADVANTAGES:

- 1-NO EXTRANEUS GAMMA RADIATION
- 2-REMOVAL OF BENIGN TUMORS WITHOUT SURGERY
- 3-EASILY ADAPTABLE TO THERAPY OF POSTOPERATIVE LESIONS

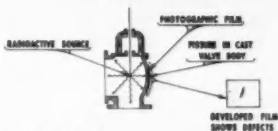
### RADIOACTIVE IODINE - $I^{131}$ FOR DIAGNOSING AND TREATING THYROID GLAND DISORDERS



#### MEDICAL ACTION:

- 1-DIAGNOSIS AND TREATMENT OF HYPERTHYROIDISM
- 2-LOCATING OF TYPICAL CANCER EPICENTERS (METASTASES)
- 3-TREATMENT OF THYROID CANCER AND METASTASES

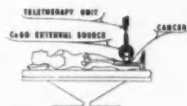
### RADIOACTIVE COBALT - $Co^{60}$ FOR RADIOGRAPHY TESTING



#### ADVANTAGES:

- 1-VISIBILE AND RELIABLE INSPECTION
- 2-INSPECTION MADE WITHOUT DISMANTLING
- 3-SOURCES OF DESIRED SHAPE AND SIZE
- 4-VERY HIGH ACTIVITY SOURCES AVAILABLE AT LOW COST

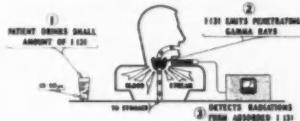
### RADIOACTIVE COBALT - $Co^{60}$ FOR EXTERNAL GAMMA RAY TREATMENT



#### ADVANTAGES:

- 1-HIGHLY PENETRATING RADIATION
- 2-RADIATION ENERGY NEARLY UNIFORM
- 3-INEXPENSIVE TO PRODUCE
- 4-GREATER INTENSITIES POSSIBLE THAN FROM RADIUM

### RADIOACTIVE IODINE - $I^{131}$ FOR STUDYING THYROID GLAND PHYSIOLOGY



#### SHOWS:

- 1-THYROID GLAND TAKES UP MOST RADIOIODINE RETAINED BY BODY
- 2-IODINE ABSORPTION PROPORTIONAL TO PRODUCTION OF THYROIDINE
- 3-RELATIVE ABSORPTION SHOWS PHYSIOLOGICAL ACTIVITY OF GLAND

### RADIOACTIVE IODINE - $I^{131}$ FOR DETECTING BRAIN TUMORS WITH RADIOACTIVE DYE



#### ADVANTAGES:

- 1-DIAGNOSIS WITHOUT SURGERY
- 2-FINDS TUMORS NOT DETECTED BY OTHER MEANS
- 3-NO DISCOMFORT OR INJURY TO PATIENT

(Continued from page 14)

radiomaterials, but also reactor time is used more efficiently.

Besides the total activity another important factor in the use of a radioelement is its specific activity, that is, the radioactivity per unit weight of element. As the specific activity is increased, smaller amounts of the element can be used for tracer or treatment applications. In tracer work the use of high specific activity radioelements permits the investigator to increase the dilution of material without interfering with its detection. It also minimizes the possible chemical effect of the material on the system or organism into which it is introduced.

Any radioelement having a half-life greater than 60 days can be appreciably increased in specific activity through extended time of irradiation in the nuclear reactor. The twenty such materials now available include radioactive calcium 45, the specific activity of which has been increased from 0.3 millicuries (radioactivity units) to 5 to 20 millicuries per gram of calcium; radioactive tantalum 182 increased from 105 millicuries to 1,000 to 3,000 millicuries per gram; and radioactive cobalt increased from 30 millicuries to 2,000 to 3,000 millicuries per gram. In radioactive cobalt, which has been suggested as a substitute for radium in certain medical treatment applications, the new high specific gravity gives a gamma ray output per unit weight approximately 3 times that of radium.

Radiosotope production by the Oak Ridge nuclear reactor has kept abreast of current demand. To make this possible it has been necessary for the operating personnel of the Oak Ridge

National Laboratory to work out procedures for the production, processing, packaging, and shipping of approximately 100 radioisotopes. Each isotope presents an independent problem because each has its own special production factors and unique nuclear properties.

### Isotope Labelling

For many tracer and medical applications radioactive materials cannot be used in the simple chemical forms that are prepared in the nuclear reactor. Radioactive and stable isotopes can be used to trace compounds through physical, plant, animal and human systems only when they have been incorporated in the particular compound to be traced. Before using radioactive sulfur, for instance, in investigating the fate of a sulfur-containing amino acid or protein in the body, it is necessary to incorporate the radio-sulfur into the specific amino acid or protein to be studied.

Labeled compounds are also becoming increasingly useful in medical diagnosis. For example, to locate certain brain tumors, investigators have used radioiodine incorporated in the dye fluorescein. The preparation and use of this special labeled compound is necessary because it is the dye and not the sodium iodide—the simple chemical form in which radioactive iodine is usually made available—which is selectively absorbed by the brain tumors.

### Isotope Farm

Some complex organic labeled compounds cannot be prepared by ordinary chemical procedures, but may be biologically synthesized by the metabolic processes of animals and plants. Radioisotopes in simple chemical form



which have been injected into or fed to an animal may subsequently be extracted from the blood, urine, or tissues as complex organic compounds. Isotope-labeled compounds may similarly be extracted from plants. Both Argonne and Oak Ridge National Laboratories have initiated programs to prepare such biologically synthesized compounds in isotope "farms." A farm in this sense is a laboratory especially equipped to handle the administration of radioisotopes to animals and plants and to extract the labeled materials.

To determine how extensively this program should expand, the Commission recently surveyed biological synthesis of radioisotope-labeled compounds in private laboratories. It found that, to date, animal and plant systems have been used to synthesize over 50 different isotope-labeled compounds. They have been labeled with radiocarbon, radiophosphorus, and radioiodine, and include such materials as glucose, fructose, ascorbic acid, nicotine, opium, and morphine. Most of the compounds have been prepared in small amounts as by-products of individual research projects and are not available to other users. The survey clearly showed a wide interest and need for these specially synthesized materials.

Recently a small amount of algae, *Scenedesmus*, labeled with radioactive carbon 14, was made available as the first product of this program. From such labeled material, radioisotope investigators can extract labeled sugars, starches, amino acids and proteins. The supply now has been completely allocated and shipped to radioisotope

users. Additional quantities of this and other biologically synthesized labeled materials are scheduled to become available in the future.

### Future of the Program

In the years ahead, as in the past, the use of isotopes may be expected to expand. A fairly large number of research centers are already using isotopes. New groups will become interested in their already demonstrated applications to scientific problems in these and other institutions as isotope techniques become more widely understood. And, as investigators become aware of the flexibility and wide adaptability of the new research tools, a great variety of new uses will be discovered that cannot be foreseen today.

A marked acceleration in the growth of the isotopes distribution program may take place if new wide scale applications are developed for use in medical practice and industry. A large portion of the uses made in these fields thus far have been fundamental research. Certain applications such as the use of radioactive isotopes in measuring thicknesses have, however, reached an advanced stage of development where the techniques are ready for routine use in applied problems. In the field of medicine certain diagnostic and therapeutic applications, such as the use of radioiodine in diagnosing and treating hyperthyroidism and the use of radiophosphorus in treating polycythemia vera, are approaching the stage of routine applicability. If such uses are widely accepted, many more groups will want to use isotopes and hence the distribution program will grow to much larger proportions.

The rapidity with which these utilizations are realized will be partially dependent on the ability of private enterprise to supply needed laboratory facilities and equipment, useful isotope-labeled compounds, new types of instrumentation, and special consultation services. Several new organizations have made contributions to these phases of the program in the past year.

Expectations are that the areas in which private enterprise can make valuable contributions will further expand. The Commission will continue to encourage wider use of isotopes through its policies of extending the availability and usefulness of isotopes and isotopic material, supporting educational programs in isotope techniques, and making available information on the feasibility and health-safety aspects of isotope utilization. The Commission has already eliminated necessities for priority distribution and is currently meeting all demands for isotopic materials, which are both feasible and safe. With its expanded facilities, it expects to meet increasingly larger demands for isotopic materials.

## *New Compound to Find Cancer*

► CREATION of a new kind of substance for finding chemicals involved in cancer and other chemicals basically responsible for muscle movement was announced recently by Dr. H. S. Bennett of the University of Washington.

The new substance is a chemical compound that contains mercury. When it combines with a special type of sulfur-containing compound, known as sulfhydryl, it signals the sulfur compound's location in red so that

The Commission has also taken direct steps to develop new uses of isotopes. In its many laboratories there are scores of isotope projects under way, a large proportion of which are exploratory in nature. Most of the new applications, the new techniques, and the new instruments and devices discovered on these projects are "unclassified" and are reported widely in the scientific world. Again, the Commission gives financial support to isotope projects in private institutions, and its present policy is to assist particularly those projects that promise to test and develop new uses of isotopes and to interest new groups of workers in their use.

Since the Congress in establishing the Commission charged it with exercising its powers so as to promote the maximum utilization of atomic energy and the maximum of scientific progress, and since isotopes today are the major gift of atomic energy to science, medicine, agriculture, and industry, the Commission will continue to foster in every possible way the wider use of isotopes in all these departments of human welfare.

the scientist can see where it is.

The new mercury red-signal compound is believed the first chemical ever created to let scientists trace body chemicals by sight. Radioactive chemicals used as tracers or tags for body chemicals signal either by the sound of the Geiger counter or by taking their own picture on an X-ray plate which then must be correlated with the optical picture of the tissue under study.

**Piezo-Electric Phenomenon  
Found in Barium Titanate**

## New Crystals For Sound Detection

by ANN EWING

► **BARIUM TITANATE**, a war-developed material with exceptional electrical behavior, will soon be replacing other crystals in submarine sound detection, and in other sound and ultrasonic equipment.

Some scientists expect that the future development of somewhat similar exceptional materials may lead to more effective electrical storage devices.

Barium titanate when treated as a ceramic, or clay-like material, looks very much like the porcelain of your kitchen sink. And it can be made in extremely thin slices needed for condensers.

At this time, scientists will admit only to pinhead size for the crystal form of barium titanate. Efforts are being made to grow crystals that are much larger.

The sensitive atoms of barium titanate show a remarkably quick response to the slightest changes in pressure, temperature, or electrical field. Even light, shining on a crystal of it, will cause the atoms to rearrange themselves.

Scientists at the Massachusetts Institute of Technology, at the National Bureau of Standards, at Bell Telephone Laboratories, and in England, Holland and Russia among other countries, are busy investigating the properties of barium titanate and related compounds.

Reason for all this intense interest is that these materials have the property known as ferro-electricity. Only two other groups of compounds are known that exhibit this property. They are the Rochelle salts and the potassium dihydrogen phosphates.

The discovery of a group of materials so far superior in their electrical behavior to any compounds yet known is as important in the electrical field as the discovery of a new class of materials that would behave as iron does in the magnetic field.

Recognition of the far-reaching effects of the new class of materials was seen in the award of the Stalin Prize of Physics in 1946 to Prof. Bentsion Vul, then head of the laboratory of dielectrics in the Institute of Physics of the USSR Academy of Sciences.

Ability to increase to an exceptionally high degree the electrical capacity of charged plates is one of barium titanate's important characteristics. Physicists speak of this ability as the material's dielectric constant. Some estimates have placed the dielectric constant for barium titanate as high as 5,000, compared with about seven for mica. These figures are based on air having a numerical value of one.

Certain materials, called piezo-electric, will develop an electrical charge when their dimensions are changed. This would happen, for instance, when they were bent or pressed mechanically. These same materials

will, conversely, change shape when they are placed in an electrical field.

It is this change in shape that makes possible the playing of a phonograph record. Here, the very tiny indentations in the groove of the record are picked up through the needle and sent back to the piezo-electric crystal. This causes a small change in the shape of the crystal. The electrical charge thus developed is amplified and comes out of the loudspeaker as sound.

Ordinarily Rochelle salts are used for this pick-up crystal, since they undergo electrical change with shape. The drawback is, however, that they lose some of this property on a very hot day, when the temperature is about 86 degrees Fahrenheit. Rochelle crystals are also very soluble in water.

Both of these difficulties are overcome in the barium titanate and related-type crystals. Experiments have shown that barium titanate does not lose its sensitivity until the temperature is well over 250 degrees Fahrenheit. Nor does it dissolve in water.

First hint of the unusual properties of barium titanate came from the

Titanium Alloy Manufacturing Company of Buffalo, N.Y. They were investigating materials suitable for use in condensers, vitally needed for the war effort. Quartz and mica, the two most commonly used materials, were in extremely short supply. Development of barium titanate suitable for commercial use in condensers did not come until late in the war effort.

Physicists at MIT, upon hearing of the exceptional qualities of barium titanate, started an investigation of its atomic structure. This was in an effort to understand why it had such an unusual behavior in an electric field.

Dr. Shepard Roberts, now at the Research Laboratory of General Electric Company, was the first to discover the ferro-electric properties of barium titanate. War-time research at MIT was led by Dr. A. von Hippel, working in cooperation with Drs. R. G. Breckenridge, F. G. Chesley and Laszlo Tisza.

Dr. B. T. Matthias, who started his investigations of the compound in Switzerland and continued them at MIT, is spearheading the work at Bell Telephone Laboratories.

## *Device Tells Amount of Oxygen*

➤ A NEW TOOL to tell how much oxygen is present in air or in other gases has been developed. Based on a device that was used during the war in military and hospital service, the machine is now available to industry. Measurement makes use of the fact that oxygen is strongly attracted to a magnet. Most other common gases are repelled by a magnet.

This magnetic property of oxygen is so great that it is possible to measure extremely small quantities of oxygen present, on the order of a few parts per million.

Credit for the theoretical basis of the instrument goes to Dr. Linus Pauling, head of the department of chemistry at California Institute of Technology.

## Oil From Shale In Scotland

► SCOTLAND next July will celebrate the hundredth anniversary of its oil-shale industry, and its production has been continuous during this period. Dr. Simon Klosky, oil-shale chemist of the U.S. Bureau of Mines, told the history of this project recently when he spoke as guest of Watson Davis, director of Science Service, on *Adventures in Science*, heard over the Columbia Broadcasting System. He reviewed the production of gasoline and heating oils from shale in Western Europe, giving information acquired during a recent inspection trip.

"In this 100 years of the Scottish oil-shale industry, it has had many ups and downs," he stated. From a flourishing start in 1850, to a temporary depression around 1880 due to importation of American petroleum, it passed to a relatively steady existence, relieved only by the demands for more liquid fuel products brought on by the two world wars.

He described a process in Sweden by which petroleum vapors and gases are obtained without mining the shale. Holes are drilled deep into the earth and into the natural layers of shale, and electric heating elements are lowered in the holes. After weeks of heating, petroleum vapors are collected from other holes. The process, he said, seems practical where plenty of cheap electricity from hydroelectric plants is available, and the price of gasoline is relatively high.

Three plants in France, visited by Dr. Klosky, were described. One has been in operation since about 1880. This refinery was operated with great difficulty during the recent German occupation, but it managed to keep going and to sequester enough of its products to refuel American combat tanks when they arrived.

Although unable to visit oil-shale industry behind the Iron Curtain, information on Estonian and Russian reserves was obtained by other means. Estonia in prewar days produced more crude oil from shale than any other country, and Russia produced almost an equal quantity. Estonian shale deposits extend eastward well into Russia proper, and the Soviets have large deposits on the Volga river and in other places.

America's entrance into the production of oil from its vast deposits was delayed behind European activities merely because the United States had vast quantities of natural petroleum. Now the point has been reached where liquid fuels from petroleum must soon be supplemented by synthetic fuels from coal and oil-shale. Dr. Klosky described two plants of the U.S. Bureau of Mines now in operation, the plant at Louisiana, Mo., for production from coal, and the plant at Rifle, Colo., where liquid fuels from oil shale are now successfully extracted.

## DuPont Builds Research Laboratories

►FUNDAMENTAL long-range research, as well as research directed toward the development of new chemical products and processes, will be the objective for which the Du Pont Company's new \$30,000,000 plant is being built, near Wilmington, Del.

Major part of this development is an entirely new section on 55 acres of what formerly was the Du Pont Country Club, an employees' club which has moved to a nearby site. The project includes ten new laboratory and semi-works buildings for long-range research and development of new chemical discoveries. Also, some of the existing laboratory buildings for nylon and other products in the older area of the station are being enlarged.

The thirteen new service buildings called for in the plans have been completed and are in use. The first of the new major units to be completed is the semi-works building for the Grasselli Chemicals Department of Du Pont. That building is now occupied.

At the time the project was undertaken, Crawford H. Greenewalt, Du Pont president, said it was being done "in the belief that in coming years research will play an ever-increasing role in the development of products needed for the high standard of living we in America have come to expect."

"Our new facilities are required to keep abreast of the keen competition in the chemical field," he said. "They

are needed for the experimental programs we now have under way and are essential for those planned for the future."

The practical effectiveness of Du Pont's past research is indicated by the fact that currently more than 60 per cent of the company's total sales volume consists of products which have been introduced or substantially developed since 1928.

When the expansion is completed, the company expects to have 900 technical employees engaged exclusively in research work at the station, of which about 200 will be transferred from other laboratory locations. Now there are approximately 500 at the station. The total of all employees there, technical and non-technical, will approximate 2,500.

The Chemical Department, which is devoted exclusively to research, will use its new facilities primarily for fundamental research with the object of discovering new scientific facts without regard to immediate commercial use. Fundamental investigations have become one of the most valuable phases of Du Pont research work in laying the foundation for new lines of applied research. In the past, it has led to nylon, among other things. Some of the new facilities for other departments will also be devoted to long-range investigations.

The Engineering Department, in its new facilities, will explore ad-



► *NEW RESEARCH plant of the Du Pont Company at Wilmington, Del., will provide facilities for all phases of study from underlying principles to semi-works production of new materials. More than sixty percent of DuPont products today have been introduced or substantially developed since 1928.*

vanced engineering problems to develop basic data on manufacturing and control equipment and construction materials.

Many of the new facilities will be used by manufacturing departments for applied as well as long-range research. The applied research programs of the manufacturing departments will include further investigations of nylon, rayon and other fibers, and films, and the development of new materials in these categories; work

aimed at major developments in pigments and related products; investigations for long-range developments of plastics; expansion of long-range research on new products and processes for agricultural and industrial chemicals, and development of products of high-pressure synthesis.

The buildings have been designed from the inside out to provide the most modern laboratories possible. The unit in this plan is a two-man



laboratory with adequate room and the latest in scientific equipment.

A typical laboratory room will be 19 by 25 feet in size and there will be about 150 of them in addition to others of different sizes for special purposes.

Extensive study was put into this

laboratory by Du Pont engineers and chemists working with the New York architectural firm of Voorhees, Walker, Foley and Smith, which prepared drawings and specifications. To develop and test it fully, a complete mock-up laboratory was built to investigate equipment, ventilation, lighting, and other factors.

## *Safe High Voltage Outdoor Cable*

► **SAFE** high-voltage cable for outdoor neon signs, recently developed with insulation made of polyethylene and chlorine compounds, was recommended to the American Institute of Electrical Engineers recently by L. F. Roehmann and E. W. Greenfield of the Anaconda Wire and Cable Company, Hastings-on-the-Hudson, N. Y. Decreased maintenance is an important result.

The new cable is safe in operation, is unaffected by moisture, contamination and salt deposits at the ends, requires no special knowledge or skill to handle, and will meet specifications relative to flame-resistance.

The development of this cable will

mean a great saving in maintenance cost of neon light signs. Some 10,000,000 feet of various types of cable were required last year in the United States for luminous signs. And despite the fact that cable used for neon signs is high-voltage, installation techniques usually follow accepted practice of low-voltage wiring.

Conclusions of tests reported by these engineers were: rubber-and-friction tape splices are not permissible in exposed sign cables; because sign cable runs are short, only continuous lengths should be used; and all-plastic insulated cables are adequate even under severe operating conditions provided the ends are properly protected.

## *Mercury Vapor and Steam Turbines*

► **MERCURY** VAPOR and steam drive turbines in a new electric plant built at Portsmouth, N.H., to increase the amount of electricity available to the State of New Hampshire. Steam turbine engines are common; mercury vapor turbines less known. In this case the two are combined to provide an economical fuel-saving plant.

In operation liquid mercury is vaporized by heat from boiler furnaces

and the vapor is used to drive the two mercury-turbines, acting in about the same way as in other gas turbine engines. After the mercury vapor has passed through the turbines, it is piped into condenser-boilers where it gives off enough latent heat in its conversion from a gaseous to a liquid condition to turn water into steam. This steam drives the steam turbine.



## For The Home Lab

# Coal Tar Dyes

by BURTON L. HAWK

► THE PREPARATION of coal-tar dyes affords interesting experiments for the home lab. Usually they are not too difficult nor too expensive to prepare. And results are usually favorable; for who does not enjoy bright colors!

When bituminous or soft coal is heated to a high temperature in a sealed retort a thick, tarry black liquid condenses which is known as *coal tar*. Perhaps you have heard of it.

### Naphthol Yellow

When coal tar is distilled, a number of important compounds are obtained. Included in the fraction which distills over from 110° to 205° is an acid oil and crude naphthalene. As this mixture cools, the naphthalene crystallizes out and is removed and purified.

Now when naphthalene is sulfonated (treated with sulfuric acid) at 0°, a compound known as *a*-naphthalene-sulfonic acid is obtained. The sodium salt of this acid is fused with sodium hydroxide to form *a*-naphthol. When *a*-naphthol is sulfonated and then nitrated a compound known technically as 2, 4-dinitro-1-naphthol-7-sulfonic acid, more commonly known as *naphthol yellow*, is obtained.

So, there you have it. Simply obtain a piece of soft coal and get to work!

But for those who do not wish to go all the way back to the coal (in-

cluding us), we suggest using *a*-naphthol as the starting point. Obtain a good grade of said chemical, and place 2 grams of it in a small flask. Add to this 5 cc. of concentrated sulfuric acid. Heat the mixture by immersing the flask in a larger container of boiling water. Keep the water boiling vigorously. The mixture in the flask should attain a temperature of 120°. Continue heating for 15 minutes; then cool and pour the contents into 15 cc. of water in a beaker. The first step of sulfonation is now completed.

Next, we proceed to the nitration process. Cool the solution to around 25° by immersing the beaker in cold water. During the nitration process, it is essential that the temperature of the liquid does not rise above 40°. It might be advisable to add a little ice to the water in which the beaker is immersed. Now add to the mixture 3 cc. of concentrated nitric acid, *a few drops at a time*. Stir the solution vigorously during the addition of the acid. This is rather tiresome, and if you have a mechanical stirrer, it certainly will be useful here. After all nitric acid has been added, continue stirring for about 30 minutes. Then allow the solution to stand for 24 hours while you recuperate.

After a day or so, naphthol yellow will crystallize out of the solution. Now you can either extract the acid as is, or you can prepare the potas-

sium salt in which form it is available commercially.

To obtain the acid, carefully pour off the liquid and transfer the crystals to another container of water. Heat to boiling for a few minutes, then filter. The deep intense yellow solution of naphthol yellow is obtained as the filtrate.

To obtain the potassium salt, separate the crystals by filtration. Wash them with a small quantity of saturated sodium chloride solution. The

crystals are then dissolved in the smallest possible quantity of hot water. Next prepare a concentrated solution of potassium carbonate and add it to the hot naphthol yellow until the solution just barely reacts alkaline with litmus. The orange-yellow crystals of the potassium salt will separate out on cooling. They can be filtered off and dried.

Naphthol yellow is used for dyeing wool and silk; for coloring foods and cosmetics.

## Phenolphthalein

No doubt you are acquainted with phenolphthalein through the lovely pink color it forms with alkalis. Or perhaps you associate this alkaline reaction with the "wine" in the magic water-to-wine experiments. But have you ever investigated or prepared the compound, phenolphthalein, itself? If not, now is your opportunity to do so.

After you learn to pronounce the name, the rest is easy. The compound is exactly what its name indicates. A phenol-phthalein. When phenol is heated with phthalic anhydride and a dehydrating agent, a *phthalein* is formed, or more specifically, a phthalein of phenol. Now if the phenol should be replaced with resorcinol, a phthalein of resorcinol (resorcinolphthalein) is formed. This compound is more commonly known as *fluorescein*.

Now what is phthalic anhydride? It is formed by heating phthalic acid. Phthalic acid is formed by the oxidation of naphthalene. So we could

say that phenolphthalein is obtained indirectly from naphthalene.

Place in a small flask 3 g. of phthalic anhydride, 6 g. of phenol (carbolic acid) and 2 cc. of con. sulfuric acid. The sulfuric acid acts as a dehydrating agent in this reaction. Now heat the mixture over a low flame until a temperature of 150 to 160 degrees is reached. Continue heating at this temperature for about one hour.

Then pour the liquid into a large beaker containing 160 cc. of hot water. Heat to boiling and stir vigorously until the odor of phenol can no longer be detected. If you have a mechanical stirrer, you can put it to use here.

Phenolphthalein is present in the mixture in crude form. You can check this by allowing a few drops from your stirring rod to fall into a solution of sodium carbonate. The characteristic pink color is obtained. But the experiment does not stop here. The purification and extraction must be carried out.

Allow the solution to cool thoroughly. Or if you wish, allow it to stand over night and continue the experiment the following day.

When cool, the solution is filtered and the precipitate containing the crude phenolphthalein is transferred to a large beaker containing 200 cc. of warm water in which 3 g. of sodium hydroxide are dissolved. Add about 1g. of decolorizing charcoal to the solution and heat for about five minutes (not to boiling) and filter again while hot. The filtrate should be colored a brilliant red due, of course, to the presence of phenolphthalein. As you have perhaps deduced, phenolphthalein is insoluble in water, but soluble in sodium hydroxide solution.

In order to obtain the phenolphthalein, it will be necessary to acidify the solution. Cool the filtrate to about 20 degrees. Then add hydrochloric acid until the red color disappears and a heavy yellowish precipitate forms. Filter off the yellow solid and wash with water. Now the phenolphthalein which you purchase

commercially is a white powder, whereas your product is yellow. This is simply a matter of further purification, and if you desire a white product, proceed as follows:

Dissolve the yellow powder in 25 cc. of ethyl alcohol; add 1 g. of decolorizing charcoal and heat (not to boiling) for a few minutes. Stir vigorously; allow to stand a few moments, then filter. Next pour the filtered alcoholic solution in small quantities into a beaker partly filled with boiling water. Stir thoroughly after each addition. Allow the solution to cool and add a few cc. of hydrochloric acid to precipitate the phenolphthalein and filter to collect the precipitate. If the product is still yellow, the above procedure is repeated. Sometimes a faint yellow color persists and it is rather difficult to obtain a pure white powder.

The chemist is very familiar with phenolphthalein through its wide use as an indicator. However, it is also used extensively in pharmaceutical preparations, in which it acts as a laxative.

## Fluorescein

► WE HAVE discussed the formation of the phthalein of phenol (*phenolphthalein*). Now we will consider the preparation of the phthalein of resorcinol (*resorcinolphthalein*). This interesting and colorful compound is more commonly known as *fluorescein*.

*Informal Preparation:* Small quantities can be prepared quickly and easily by the following method:

In a large test tube place a small

quantity, about  $\frac{1}{2}$  gram, of resorcinol (resorcin) and one-half as much ( $\frac{1}{4}$  gram) phthalic anhydride. Add 10 drops of con. sulfuric acid and heat the mixture to boiling for two or three minutes. Then *carefully* pour the hot mixture into a beaker containing 15 cc. of water. The crude fluorescein separates as a yellowish-red precipitate. The product prepared in this manner is very crude, but it will be sufficiently pure for our purposes.

## Multi-Colors

Pour a little of the suspended fluorescein in a test tube and add a solution of sodium hydroxide. Heat gently to dissolve the precipitate, then filter. Examine the filtrate. Hold it at different angles in respect to transmitted and reflected light. You will note that the solution is yellow by transmitted light and green by reflected light. Now heat the solution again and add about 2 cc. of dilute hydrochloric acid. Again note the color change.

Actually, the alkaline solution is a sodium salt of fluorescein, sometimes known as Uranine Yellow, and is soluble in water. Fluorescein itself is insoluble in water.

## Formal Preparation

Because of its rather unusual properties, you may wish to prepare fluorescein in larger quantities for further experimentation. If so, it is advisable to use zinc chloride instead of the sulfuric acid as described above.

Place in a large beaker five grams of phthalic anhydride and seven grams of resorcinol. Heat the mixture to 180°, preferable in an oil bath if possible. When this temperature is reached, add in small portions four grams of pulverized fused (anhydrous) zinc chloride. Stirring occasionally, continue heating until the mixture becomes solid. This will usually require about one hour, more or less. Then cool and scrape the solid mass from the beaker. Pulverize in a mortar and boil the powder in a solution of five cc. hydrochloric acid and 75 cc. water. Finally, filter the fluorescein, wash and dry. Again the product is not pure, but sufficiently so for the preparation of eosin. However, if you desire, further

purification can be obtained by dissolving the fluorescein in hot dilute sodium hydroxide, and reprecipitating with acid.

## Eosin

Eosin (tetrabromofluorescein) is used as a dye, usually in the form of its sodium salt which is soluble in water. To prepare it, shake one gram of fluorescein in six cc. of 95% alcohol. Carefully add, drop by drop, about one-half cc. of bromine. The fluorescein will gradually dissolve to form first the soluble dibromofluorescein and finally the insoluble tetrabromofluorescein. If the latter is not precipitated, add a few additional drops of bromine. Pour the mixture into 15 cc. of water, stir and filter off the eosin. Suspend the crude eosin in water and add dilute sodium hydroxide solution until entirely dissolved. Now pour the solution into 10 cc. of boiling water to which one cc. of hydrochloric acid has been added. Finally, filter off the orange-red eosin.

To prepare the soluble sodium salt of eosin, mix thoroughly together in a mortar one gram of dry eosin with  $\frac{1}{2}$  gram anhydrous sodium carbonate. Make into a paste with ethyl alcohol. Add one cc. of water, transfer to a test tube and heat gently until evolution of gas ( $\text{CO}_2$ ) ceases. Then add five cc. ethyl alcohol, heat to boiling and filter the hot solution. Allow the filtrate to stand. Eventually, green-red iridescent needles of the sodium salt will crystallize out of solution.

This is the commercial form of eosin which is used in red inks, as a dye for wool and silk, and as coloring for lipstick and nail polish.

As stated previously the sodium salt of eosin is soluble in water. The con-

centrated solution is deep brownish red whereas the dilute solution is yellowish-red with greenish fluorescence.

### **Preparation of Bromine**

If you do not have bromine, the small amount needed for preparing eosin can easily be made. Simply mix together equal quantities (not more than one gram each) of potassium bro-

mide and manganese dioxide in a test tube. Add one cc. of sulfuric acid and attach a delivery tube leading to another test tube immersed in a beaker of ice water. Heat gently. Bromine is liberated and will condense in the cool receiving tube. Be very careful not to inhale the fumes or spill the liquid on the skin.

## *Red-Blue Powder Locates Trouble*

► PRINTERS can now sprinkle a new powder on sheets of paper to spot the troublesome static electricity that makes the paper running off the presses stick together.

A duplex red-blue powder, developed by Harry H. Hull of R. R. Donnelley and Sons Company, Chicago, tells where the positive and negative electrical charges are located. Red spots the positive areas and blue the negative.

Using this special powder, printers can now tell the best place to put the grounded Christmas tree tinsel they often use to neutralize static. Or they can use the powder to judge how efficient one kind of static eliminator is compared with another.

Not only the presses, but also the machines that fold paper generate

electricity. Mr. Hull has found that paper from either presses or folding machines often has both positive and negative charges quite close together on the same sheet.

The special powder is a mixture of red and blue powders. The blue is dyed lycopodium powder, spores of the plant that is widely used to make Christmas wreaths. The red dye, carmine, is mixed with sulfur to make the part of the powder that is attracted to the positive areas.

Many drugstores carry both lycopodium powder and carmine. When a glass rod is used to write upon cellophane, and the cellophane dusted with the powder, the writing outline is blue. Other parts of the cellophane attract the red part of the powder. Mr. Hull believes that this is due to friction with the writing surface.

## *Industrial Microbiologists Organize*

► SWARMING microorganisms have a new scientific society to study them. It is the Society of Industrial Microbiologists, formed during recent science meetings in New York City. The new group will pay special attention to microscopic life that destroys clothing, building materials and other sub-

stances. The organisms that produce the antibiotics, such as penicillin, yeasts that yield alcohol in beer and liquor, and bacteria that produce useful chemicals are in the field of the society. Dr. Charles Thom of Jeffersonville, N. Y., is the first president.

## Metal Shrinks Instead of Expanding When Heated

# Polonium Has Unique Property

► **DISCOVERY** of the first metallic element yet known that shrinks instead of expanding when heated has been made in Los Alamos as a by-product of the atomic bomb work.

The metal element is the highly radioactive polonium. This metal looks a lot like lead and resembles lead in its physical properties, Dr. Charles R. Maxwell, Dr. William H. Beamer and William E. Easton of the Atomic Energy Commission's Scientific Laboratory have found. They were investigating the physical properties of polonium for the first time.

Heretofore this metal, discovered by Madame Curie in 1898, has been available in such minute quantities that no measurements could be made of its physical properties. With the larger though still very small amounts available from the Manhattan Project during the war, these scientists investigated the physical properties of polonium.

For the first time in a pure element they observed simple cubic crystal structure. The cubic structure is a basic crystal structure, yet has never before been observed in an element.

Hero's aeolipile, a hollow sphere caused to rotate by escaping steam, was developed nearly 2,000 years ago and is the first recorded use of jet propulsion by which some airplanes are now driven.

Infra-red rays are used to photograph valuable old paintings to aid research into the techniques of the old masters; they penetrate through the upper layers of paint and reveal the sub-surface modelling.

There is no theoretical explanation yet to explain the cubic crystal form in polonium.

Polonium is often used in extremely small quantities to paint the figures on luminous watch dials. It is named in honor of Madame Curie's native country, Poland.

Lead is the element into which polonium decomposes when it shoots off alpha rays. Alpha rays, the most easily absorbed of all radioactive radiations, are actually the hearts, or nuclei, of helium atoms.

Besides investigating the way that one form of the metal reacts when heated, and its cubic crystal structure, the scientists also found that polonium melts at 590 degrees Fahrenheit and has a density of 9.4 grams per cubic centimeter. That means that polonium weighs 9.4 times as much as the same volume of water.

Gauge of the radiation activity of an element is by means of its so-called half-life. This is the length of time required for half the radioactivity originally present to be shot out from the material. Polonium has a half life of 138.3 days.

## Remedies Range From Leprosy To Radiation Sickness Aids

# Drugs For New and Ancient Ills

►AUREOMYCIN, the golden-yellow drug from a mold, may become one of our best weapons against atomic bombs.

It has already shown ability to cut the death rate from killing and near-killing doses of radiation in animals.

This "highly important advance" in medical defense against death from the radiation effects of atom bombs was made at the Atomic Energy Project at the University of Rochester, N. Y. It was disclosed in the report of the Atomic Energy Commission.

Following this discovery of aureomycin's anti-radiation effects, the effects of other antibiotics, such as penicillin and streptomycin on acute radiation sickness are being studied.

These drugs had already been considered as valuable medical weapons in case of atomic attack because of their ability to control infection. Persons damaged by radiation are markedly sensitive to germ infection. Many of the Japanese victims at Hiroshima and Nagasaki developed extensive ulceration and blood poisoning because of this post-radiation sensitivity.

Lead shields around the spleen and inhalation of nitrogen instead of air are other measures which AEC scientists found decreased the death rate in experimental animals. Lead belts, reminiscent of gangsters' bullet-proof vests, might be worn by anyone expecting an atomic attack but breathing nitrogen instead of air is hardly practical, since it would lead to death

by suffocation instead of by radiation.

### Weapon Against Leprosy

►A NEW WAY to use an old drug may provide a cheap, effective weapon against leprosy. The drug is diamino-diphenyl sulfone, first synthesized in 1908. Good results with its modern use are reported by Dr. John Lowe, research director of the Nigerian Leprosy Service, in the *Lancet*, London medical journal.

The drug was formerly thought too toxic to be given to humans. But, Dr. Lowe reports, it is perfectly safe when given by mouth, starting with a small daily dose and gradually increasing the size of the dose.

Of 50 patients treated, 72% improved, 62% showing improvement by bacteriological tests. In the remaining patients, the disease was arrested.

Most important from the standpoint of treatment of thousands of poor natives afflicted with leprosy, Dr. Lowe states, is the low cost of the drug, amounting to one or two dollars per year. The daily cost of treatment with this drug is only one-twentieth that of treatment with the proprietary sulfones such as promin, diasone and sulphetrone.

Possible importance for the drug in the treatment of tuberculosis is also suggested by Dr. Lowe.

### Cortisone For Arthritis

►A NEW WAY of using cortisone to treat rheumatoid arthritis is giving "encouraging" results, the discoverer

of the drug, Dr. Edward C. Kendall of the Mayo Clinic, reported to an American Chemical Society meeting recently.

Time is an important factor in the treatment, research at the Mayo Clinic shows.

If cortisone is given to a patient with rheumatoid arthritis for two weeks and use of it is then stopped, the symptoms return promptly and sometimes in an aggravated form, Dr. Kendall said.

If cortisone is again administered for two weeks and stopped, the symptoms may return more slowly and in milder form. This type of treatment is now under investigation. The results have been encouraging.

The best method of using the drug for arthritis and rheumatic fever has not yet been worked out.

The only avenue of supply which can furnish an unlimited amount of cortisone is total synthesis from simple chemicals in the laboratory, Dr. Kendall declared. It may be months or perhaps even years before this is achieved.

At present it is partly synthesized starting with ox or sheep bile. The yield is so small, however, that 40 head of cattle are needed to provide the cortisone needed by one patient for one day.

### **ACTH Against Blindness**

➤ ACTH, the anti-arthritis hormone from the pituitary gland, is now entering the fight against blindness.

Cautiously, because the work is still in a very preliminary stage, two New York eye specialist physicians report trials of the drug in a few cases of iritis, choroiditis and uveitis, inflam-

matory conditions within the eye.

The effects in these eye disease cases parallel those in rheumatoid arthritis. The patients get better while under treatment. When the drug is stopped, the eye trouble comes back.

The results show the drug deserves further investigation in these eye conditions, the eye specialists, Drs. John M. McLean and Daniel M. Gordon, of New York Hospital-Cornell Medical Center, state in a report to the Association for Research in Ophthalmology.

The particular eye diseases for which they have tried ACTH are inflammatory conditions akin to the inflammatory conditions in rheumatic joints and in rheumatic fever. They reported on only six cases but are continuing their research with ACTH. They have not yet done any work with cortisone, the adrenal gland hormone which was the first of the two now famous anti-arthritis drugs.

### **Cells Build Resistance**

➤ DEVELOPMENT of drug resistance by leukemic cells may be the reason why leukemia patients get only temporary improvement from treatment with anti-folic acid chemicals such as aminopterin and amethopterin.

Complete resistance to one of these drugs has been brought on in one strain of leukemic mice by continued treatment, generation after generation, although untreated mice from the same strain continued to be sensitive to the effects of the drug.

The experiments which led to development of this drug resistance in the leukemic mice are reported by Drs. J. H. Burchenal, E. Robinson, S. F. Johnston and M. N. Kushida, of the Sloan-Kettering Institute for Cancer Research, in the journal, *Science*.



Cells of the drug-resistant and sensitive mice show no difference in size and structure. The scientists are now trying to learn whether there are chemical differences in the cells.

### Cell Changes in Cancer

► CHEMICAL CHANGES in body cells when they become cancerous are reported by Dr. A. Clark Griffin and associates at Stanford University.

When rats are fed a diet containing

a dye which produces cancer of the liver, there is an increase within the cell of the amount of a chemical, desoxyribonucleoprotein, which is important in the growth and organization of the cell. At the same time there is a decrease in the amount of vitamin B<sub>2</sub>, or riboflavin.

These changes may in some cases, Dr. Griffin and associates believe, cause cancer cells to develop from normal cells.

## Defective Molecules Show Disease

► DEFECTIVE giant molecules in the blood may give doctors a way of detecting the most serious form of hardening of the arteries before symptoms of the disease appear.

These defective molecules and their relation to the artery hardening called atherosclerosis were discovered in efforts to learn more about the effects of atom bomb and other radiation.

The findings are announced by Dr. John W. Gofman and associates of the University of California in the journal, *Science*.

Many giant molecules carried in the blood have as one of their components the fatty chemical, cholesterol. This chemical has long been suspected of being involved in the particularly fatal artery hardening condition called atherosclerosis.

One type of cholesterol-bearing giant molecule, can be present in the blood without any atherosclerosis be-

ing present, the California scientists discovered. But when certain other, apparently defective giant molecules with cholesterol in them are in the blood, atherosclerosis is also present.

One of the differences between the two kinds of molecules is in their content of protein. The defective ones contain little or none in contrast to the other cholesterol-bearing molecules which have a protein content of 25% by weight.

When patients were put on a diet restricted in cholesterol or fat, within two weeks to one month the number of the defective giant molecules was definitely reduced or even brought to such a low level that they could not be detected.

Detection of the giant molecules and distinguishing the defective ones from the non-defectives involves the use of an ultracentrifuge which spins at a rate of 60,000 revolutions per minute.

Grass will grow on rocky road shoulders if from 5% to 10% of clay soil and some fertilizer are added.

**Potassium, Nitrogen Phosphorus •  
Replenish Soil, Improve Crops**

## Back to the Land

*Reprinted from the INDUSTRIAL BULLETIN of Arthur D. Little, Inc.*

➤ ONLY NOW is the fertilizer industry emerging from its wartime turmoil to a point where it can review the changes of the past ten years. During that period tonnage output has risen 160 per cent, a remarkable feat for a basic industry. Imports of one fertilizer material from Europe, which were previously important, have disappeared, new regional markets have grown up, the farmer has become more receptive to the fertilizer salesman, and new forms of fertilizer and fertilizer application have become common. Farm prosperity is the immediate cause for the record 1949 production of 18 million tons, which will probably not be exceeded for several years, but the farmers' new recognition of the value of fertilizer will help to prevent repetition of the severe slumps which have plagued the industry in the past.

The principal plant foods incorporated in fertilizers are nitrogen, phosphate, and potash, but increasing recognition is being given to the secondary and trace elements, such as calcium, magnesium, boron and manganese. Fertilizer manufacture is the leading outlet for chemicals, on a tonnage basis. Synthetic nitrogen and potash for fertilizer are produced by less than 20 manufacturers usually located near the sources of raw materials, while there are 195 phosphate plants, and nearly 1000 plants manu-

facturing mixed fertilizers scattered throughout the country.

Synthetic ammonia provides 600,000 tons of nitrogen for commercially produced fertilizer, which consumes about two-thirds of the annual ammonia production. The remaining 400,000 tons of nitrogen used in fertilizer are provided by ammonium sulfate and ammonia liquor derived as a by-product of coal coking, by 200,000 tons of imports, and by natural materials such as sewage and cottonseed meal.

Much of the synthetic ammonia capacity now used for fertilizer manufacture was created to provide raw materials for explosives during the war. Ten plants with a total capacity of 970,000 tons of ammonia were constructed for this purpose, and actual production in some of these units has exceeded design capacity by as much as a third. Six are now used commercially, but even these plants have not supplied enough ammonia, and since the war an additional 260,000 tons of capacity have been added.

Superphosphates, either ordinary or concentrated, provide virtually all the phosphate in fertilizers. Ordinary superphosphate is made by treating finely ground phosphate rock with sulfuric acid. Superphosphate is the chief market for sulfuric acid, taking over 3.2 million tons last year. This process converts the phosphate in the

rock to a form more readily available to plants; the product contains 18 to 21 per cent plant food, which represents a lower percentage of phosphate than was in the original rock. Concentrated, or triple, superphosphate, is made by reacting the rock with phosphoric acid, to yield a plant food content of 45 to 48 per cent. The ordinary superphosphate is usually produced in relatively small plants near the point of use, although Baltimore is the largest producing center, taking advantage of low rates for water shipment. Farmer coöperatives have become increasingly important, although they still account for only four per cent of manufacturing capacity.

The concentrated product is more economical to ship, package, and handle, on the basis of plant food content. Most plants are located near the rock mines in Florida, Tennessee, and Idaho, or at ports where the rock is received at low cost. More use of concentrated superphosphate is expected, since it can deliver plant-food units to the farmer in many locations more cheaply than can locally produced ordinary superphosphate. Capacity has already increased from 500,000 tons in 1946 to over 750,000 tons now.

Over 80 per cent of the potash used comes from vast underground deposits near Carlsbad, New Mexico, with most of the rest produced at Searles Lake, California. Imports from Europe, important until the war, are now insignificant, but some may come in soon to provide dollar credits.

Most important reason for the long-term growth in use of fertilizers is the exhaustion of plant food from the

soil. For example, a bushel of corn takes about a pound of nitrogen, 0.4 pound of phosphate, and 0.3 pound of potash from the soil. While a portion of these nutrients may be replaced naturally, removal exceeds replacement several-fold in some areas. This is especially true in the Middle West, where the transition to hybrid corn made heavy demands on the soil. Iowa has shown one of the most startling increases in fertilizer application, with use jumping from 13,000 tons in 1939 to 309,000 tons in 1948; growth in adjacent states has been of the same order of magnitude. The central states, extending from Ohio to Missouri and the Dakotas, now account for 25 per cent of the plant foods used.

In some of the southeastern states, however, addition of plant food to the soil is up to ten times as much as that removed by crops. Even in such cases, high rates of application can usually be justified on the basis of additional revenue from a larger crop. For corn, it is estimated that one dollar's worth of fertilizer may yield eight dollars' worth of additional crop. Although mounting fertilizer application can reach the point of diminishing returns, it has been estimated conservatively that, throughout the United States, 16 per cent more nitrogen, 45 per cent more phosphate, and 33 per cent more potash can be used before this point is reached.

Cash farm income has traditionally been an index of fertilizer consumption; income is now about three times the prewar level, and has grown slightly faster than expenditures for fertilizer. Recently, probable crop

prices for the next season, adjusted to changes in the purchasing power of farmers, have influenced fertilizer consumption. Continued research and education through farm demonstrations by Government agencies, trade associations, and manufacturers are now reflected in improved farming practices. One program of special interest is the use of radioactive tagged atoms to study the manner in which plant foods are used. Such work has indicated that a large part of the phosphate absorbed by a plant in its initial stages of growth is derived from the

current season's application, even when there is a large reserve of phosphate in the soil.

The quantity of each plant food used is influenced by the soil needs of different sections of the country. In general, the ratio has been 1:2:1, with phosphate accounting for almost the same tonnage as potash and nitrogen combined. Many agronomists expect that this ratio will shift, and that a 1:1:1 ratio will be used in many parts of the country within the next twenty years.

## *Insecticide Alters Plant Heredity*

► BENZENE hexachloride, one of the powerful new insecticides, is capable of producing drastic hereditary changes in plants by multiplying their chromosome counts, after the fashion of colchicine. Dr. Dontcho Kostoff, of the Academy of Science in Sofia, Bulgaria, has reported.

Benzene hexachloride, known also by the longer chemical name of hexachlorocyclohexane, was used in several forms in Dr. Kostoff's experiments, and applied to a number of plants ranging from corn and wheat to sunflower and mustard. Many of the new, giant, multichromosome cells were abortive, but large numbers of them were capable of reproduction, continuing their novel kind.

Dr. Kostoff sees two possible significances in his discovery. The first may be beneficial: "The effect of hexachlorocyclohexane is so striking that it can be used as a polyploidizing agent, es-

pecially when one considers that it is much cheaper than other such agents."

The second possible significance is not so good, and leads to a warning: "Such insecticides or fungicides, when applied, may increase hereditary changes in cultivated varieties ("pure lines"), leading thus to more rapid degeneration of the highly bred, uniform varieties. This means that when such insecticides or fungicides are applied the seeds of the propagated varieties should be changed more often so as to secure new nondegenerated stocks."

Slightly over a decade ago Dr. Kostoff attracted the attention of geneticists, and of biologists generally, by his discovery of similar effects produced by a different chemical, acenaphthene. He was at that time working in Moscow, at the Academy of Sciences of the USSR.

Shellac is the only commercial resin obtained from animal chemical reactions.

## New Patents Use Chemicals To Produce Novel Results

# Chemical Patents in the News

*Copies of patents may be ordered from the U.S. Commissioner of Patents, Washington 25, D.C., at twenty-five cents each. Order by number and enclose remittance in coin, money order or Patent Office coupon, but not stamps.*

### Heat-Resistant Paint

► LESS DANGER from fire is promised with a heat-resistant paint, capable of withstanding temperatures in the range of 850 to 1,200 degrees Fahrenheit.

The patent number is 2,495,306, and the recipient is Paul Zurcher, Ponca City, Okla. His paint contains methyl silicone resin, boric acid and a lead compound. The lead compound used, such as lead oxide, is capable of reacting with the boric acid at an elevated temperature to form a lead borate.

### High Frequency Cooker

► A HIGH FREQUENCY electromagnetic cooking apparatus, particularly for fruits and vegetables in canning, requires a special container for the food. Instead of the familiar all-metal can, the special container may be all plastic, or have a metal cylindrical part with ends of a dielectric material, such as a suitable plastic. It must be made of a material that will permit high-frequency energy to pass through the food and do the cooking. The advantage is rapidity and thoroughness. The apparatus includes a source of

high-frequency energy, such as a magnetron oscillator, and what the inventors call a wave guide. This is a tube through which the food containers pass, where their contents are subjected to the high-frequency waves. Laurence K. Marshall, Cambridge, Mass., received patent 2,495,415 for this device. It has been assigned to Raytheon Manufacturing Company, Newton, Mass.

### Air-Conditioned Cranes

► RELIEF from heat and fumes to overhead crane operators is provided in ventilating and air-conditioning apparatus for which Eldon H. Lusk, Sharon, Mass., received patent 2,495,376. These overhead cranes travel on tracks in foundries above moulds and furnaces. Patent rights have been assigned to Westinghouse of Pittsburgh, Pa. This invention has other applications in addition to those in foundries. It brings to the moving cab fresh and cooled air from outside the building. Mechanical refrigeration within the cab could bring a comfortable temperature but would not eliminate the objectionable fumes from operations in the plant.

### Removes Burns From Tubes

► A METHOD of removing burns from cathode-ray tubes, such as used in television, brought Arthur Bramley, Long Branch, and Carl E. Swanson, North Arlington, N.J., patent 2,495,203. It has been assigned to Philco Corpora-

tion, Philadelphia. These so-called burns may be produced by ion or electron bombardment on the luminescent phosphor or the glass of the face plate of the tube.

### **Desalting Sea Water**

► A COMPRESSED BRIQUETTE of chemicals which will desalt sea water and which will disintegrate quickly in water has been invented by Howard L. Tiger, Hewlett, N.Y., and assigned to the Permutit Company of New York. The patent number is 2,494,784. The briquette, which contains a silver alumino-silicate cation exchanger, is forced into a small shape under a great deal of pressure, for carrying on airplane life rafts. However, the inventor claims, without the addition of a material to make the chemicals disintegrate quickly, the briquette is ineffective. Mr. Tiger has added from two to five per cent of wilkinitite to the briquette and claims that it will then disintegrate within three minutes and get to work desalting sea water.

### **Camera Patents Issued**

► INVENTORS of the camera which produces a positive print within two minutes after the picture has been taken, have received three patents on their invention. They are O. E. Wolff, patent number 2,495,112, Millard T. Gannon, number 2,495,113 and Edwin H. Land, 2,495,111. The three inventors, all of Cambridge, Mass., have assigned their invention to the Polaroid Corporation, also of Cambridge.

### **Cool Spark Plugs**

► AIR-COOLED spark plug, designed for use in the high temperatures of

gas turbine combustion chambers, brought John A. Benson, Nahant, Mass., patent 2,493,743. It may also be used in rocket or reaction type motors and other combustion apparatus. An important object of the invention is to prevent fouling of the igniter with unburned fuel or carbonized particles on the electrodes. Its feature is a nozzle adapted to discharge a jet of cooling and insulating fluid under pressure against the electrodes. Patent rights have been assigned to General Electric, Schenectady, N.Y.

### **Antistatic Film**

► PHOTOGRAPHIC FILM, protected against static electricity, will be appreciated by the many who have experienced trouble with foggy patterns on the developed films due to accumulation of electric charges on them. It is a rather frequent occurrence. These charges are produced by the friction of the film moving over rollers or past the gates of a camera. Patent 2,494,054 was issued to Gale F. Nadeau and Walter R. White, Rochester, N.Y., for this antistatic film. Rights have been assigned to the Eastman Kodak Company of the same city. In their invention, cellulose nitrate, acetate or acetate propionate photographic film is coated with a layer of succinonitrile.

### **For Etching Glass**

► AN IMPROVED preparation to etch or frost glass earned George McKay, Garden City, N.Y., patent 2,493,984. Hydrofluoric acid has long been used for this purpose. The effective life of the conventional hydrofluoric acid etching solution is not as long as desired. Mr. McKay's new material is

hydrofluoric acid to which activated carbon has been added. The carbon, he says, lengthens the useful life of the solution to a great extent. Patent rights are assigned to McKay Chemical Company, Inc., Brooklyn, N.Y.

#### **Four-Color Photo Film**

➤ A NEW, four-color, light-sensitive photographic film which permits the photographer to develop separately the three primary colors and black has been patented and assigned to the E. I. du Pont de Nemours & Company by Joseph A. Ball, Los Angeles, Andrew B. Jennings, New Brunswick, N.J., and Otis W. Murray, Burbank, Calif. The film consists of four different light-sensitive layers, separated by stripping separator layers. Each of the layers can be stripped off for separate developing, or else the four can be developed together to provide a full-color negative.

The film has been patented in three different forms, in patents numbered 2,492,952 to 2,492,954. One of the patents says the film would be especially useful in four-color photographic processes already owned by Du Pont. Two of these forms are essentially similar. In one version of the new film, all four color strips are bound together, divided by separator strips. Three of the four color strips are strippable from the supporting or separating layer. In the other version, there are two separate film elements, each consisting of two color-sensitive film strips, separated by and bound with transparent strips. They are adapted for simultaneous use in a

beam-splitting camera for multi-color photography.

#### **Fire-Proof Paper**

➤ A NEW HEAVY insulating and fire-proof paper has been patented and assigned to the General Electric Company by Theodore R. Walters of Pittsfield, Mass. Patent 2,493,604 was awarded him. The paper is made of extremely thin fibers of asbestos impregnated with a hydrated colloidal clay, like bentonite.

The inventor claims that, heretofore, it was not possible to make asbestos paper of sufficient tensile strength for ordinary use that was also non-conductive of electricity. To make such paper strong enough, it is said, it was previously necessary to incorporate cotton fibers and other products which conducted electricity. Also present in natural asbestos were iron oxide and conducting salts. Heretofore, the addition of clay to paper has weakened the resulting product's tensile strength. Clay was used in paper for the purpose of improving the finish of the paper. Now, the inventor claims, his process not only makes unnecessary the inclusion of strengthening cotton fibers, but also gets rid of the natural conducting materials in asbestos. Further, it combines the clay with the asbestos fibers in such a way as to strengthen the resulting material. When finished, the material, while still damp, can be wrapped around transformers so that they can be operated at much higher temperatures. In heavy, thick form, when dry, the material can be cut or sawed like any similar material.

Mexico is actively looking for petroleum deposits for the first time in six years.

## Storms on the Sun

*A recent radio talk over the network of the Columbia Broadcasting System in which, on the Science Service program, "Adventures in Science," Dr. Donald H. Menzel of Harvard University was interviewed by Watson Davis Director of Science Service. Dr. Menzel described the surface activity of the sun. New information about the gases that make up that surface is constantly being mapped by Dr. Menzel and his associates with the aid of a new instrument, the coronagraph.*

DAVIS: No part of the heavens is more important to us than the sun. It is the earth's power house. The sunshine makes the crops grow. What would we do for songs without the sun? It affects the earth in less obvious ways, such as affecting radio communication. So today we take a new look at the sun, with the help of our Adventures in Science guest who is Dr. Donald H. Menzel, associate director for solar research of the Harvard College Observatory. Dr. Menzel and his associates have been observing the sun with novel instruments on a mountain peak in Colorado. You have captured a motion picture record of great storms on the sun, Dr. Menzel. Won't you tell us about them?

MENZEL: Our motion picture showed great clouds of shining gas

raining down on the sun from enormous heights above the surface.

DAVIS: Just what do you mean by "enormous"?

MENZEL: The actual heights vary a good deal but rain falling from fifty thousand miles is commonplace. Frequently we will see it coming down in long graceful curves from heights as great as a quarter of a million miles. And falling with speeds ranging from 10 miles a second up to perhaps a hundred miles or more a second.

DAVIS: These clouds of what you call "rain" consist of luminous gas. What makes them shine?

MENZEL: They shine because the gas, which is mostly hydrogen, is extremely hot. Even now we are not quite sure why the gas is so terribly hot, four times hotter even than the normal shining surface of the sun. But probably some of the effect results from magnetic fields on the sun.

DAVIS: Magnetic fields? Well, we'll come back to that in a moment, Dr. Menzel, but first I should like to ask you another question. You say that you see the material raining down. Do you see it going up? Where does it come from?

MENZEL: Well, Mr. Davis, we scientists usually agree that what comes down must have gone up. But here we see material coming down far more frequently and in much greater volume than we do going up.



Occasionally there are upward streams of material, great surges of gas that rise perhaps a quarter of a million miles—sometimes even as high as a million miles. Some of these surges look like super-giant geysers, whose width is greater even than our earth. Sometimes we see small puffs—if you call puffs of gas about the size of our earth small—shooting up with great speeds. However most of this material seems to cascade immediately back upon the solar surface. Such eruptions, however, probably do not cause what I've called rain.

DAVIS: Where do you think the solar rain comes from, then?

MENZEL: Some years ago, Dr. Walter Roberts, one of my close associates and colleagues in this work, discovered a phenomenon that he calls the spicules, "little spikes." These spicules consist of bubbling jets of gas that form, for the most part, near the poles of the sun. Here most of the material seems to be rising and there is no appreciable evidence that it returns to the surface of the sun. My own guess is that this spicule matter, which rapidly becomes invisible as the gas thins and rises, eventually moves out over great distances and finally cascades in near the sun's equator.

DAVIS: How are these pictures taken, Dr. Menzel, and where?

MENZEL: We use an instrument known as a "coronagraph," one of which is located at Climax, Colorado. Harvard and the University of Colorado operate the station jointly, under the sponsorship of the U. S. Navy and the National Bureau of Standards. Then we have a second coronagraph recently installed at Sacramento Peak,

New Mexico, under the sponsorship of the Air Forces.

DAVIS: Climax, that sounds pretty high!

MENZEL: And you are right, it is more than two miles above sea level—high in the highest part of the Colorado Rockies. We go to these altitudes because of the clear blue skies we find there. They are far bluer than any we normally observe at sea level or at reasonably low altitude. Incidentally, you might be interested to know that these two coronagraphs are the only ones in the western hemisphere at the present time.

DAVIS: Just what is a coronagraph and how does it operate?

MENZEL: A coronagraph is a special instrument, a very perfect type of telescope, or, rather a telescope with a very perfect lens. The lens must be made of the very finest glass, free from bubbles and scratches, and completely free from dust in addition. The slightest imperfections scatter light and make it impossible for us to see the fainter appendages of the sun that lie beyond its shining disk.

DAVIS: How do you get away from the effect of the bright sunlight, then?

MENZEL: Near the focus of the first lens we put in a small disk, like a twenty-five cent piece, which just eclipses the sun—artificially. Then, with a second lens we record the exterior portions of the sun and its atmosphere on a photographic film or plate. Usually we take motion pictures of the sun.

DAVIS: I understand that you take these pictures very slowly, say one

every half minute or so, so that the solar action appears greatly speeded up on the screen.

MENZEL: Yes, Mr. Davis. We speed them up usually about six hundred times.

DAVIS: Earlier you mentioned the sun's magnetic field. Tell us why you think that magnetic effects are present.

MENZEL: Well, for one thing, the material that falls moves much more slowly than we should expect under the intense pull of the sun's gravitation. Something is slowing down the matter, and some theoretical studies I have carried out recently indicate that magnetic fields are probably responsible.

DAVIS: Can you give us an idea as to how a magnetic field acts?

MENZEL: Well, I can give you a sort of analogy. The magnetic field has associated with it invisible "lines of force" which extend out into space all around the sun in a fairly regular pattern. Now, the great luminous clouds that I have mentioned become entangled in this mesh of lines. The lines tend to support the material—unless too much of the material accumulates. Then these lines, which are partially elastic, tend to sag and form a pocket into which the surrounding gas tumbles more and more. Finally the magnetic roof of the sun, over certain regions, will collapse and fall to the solar surface.

DAVIS: What happens then?

MENZEL: Nothing much happens until some of the material leaks away, as if it were a bunch of snow melting. But when the amount diminishes

far enough, then the normal elasticity of the lines of force reasserts itself and flings the material back out into space, like a catapult.

DAVIS: Does any of this material ever reach the earth?

MENZEL: Yes, I think so. On occasion we have very brilliant displays of northern lights, or aurora borealis, probably caused by clouds of gas striking the earth, after having been shot away from the sun.

DAVIS: What evidence is there that this happens, Dr. Menzel?

MENZEL: I have some new evidence, Mr. Davis, gathered within the last month. Most of my original ideas came from studies of the motion pictures taken at Climax, supplemented by mathematical analyses. These prominences or luminous clouds represent the denser portions of the sun's atmosphere, as they are compressed by the magnetic field and fall to earth—or more accurately, I should say fall to sun. But I think that the matter that descends invisibly, of which we have spoken before, may be the material that shines dimly in the sun's corona.

DAVIS: You mean the corona that we ordinarily view only at time of total solar eclipse?

MENZEL: Yes, the corona is a sort of halo that surrounds the sun and usually shows the characteristic pattern of the sun's normal magnetic field. However, some photographs of the corona that I recently borrowed from Lick Observatory in California, show a very close relationship between the faint corona and the brighter prominences. In one particularly striking instance, the corona appears

crumpled and bent under the weight of a specially large prominence.

DAVIS: And you regard that effect as supporting your new solar theory?

MENZEL: Yes, I do. But there are still many, many interesting problems yet to solve. Among them we must have better answers as to how and why the sun seems to have an effect upon the earth. Variations in the sun's output of radiation cause disturbances in the upper earth's atmosphere, disturbances that affect and sometimes completely interrupt radio communications, especially on the short waves.

DAVIS: Are these explosive outbursts in the solar atmosphere phenomena akin to the so-called "hydrogen bomb," so much discussed these days?

MENZEL: Any resemblance between solar eruptions and the hydrogen bomb is largely coincidental. There are no atomic explosions going on in the sun's atmosphere. And although we occasionally get a bomb-like formation, complete even to the mushroom cap, there is no direct connection between such an explosion and hydrogen or uranium bombs.

DAVIS: Well, are the energies of the explosions comparable?

MENZEL: Any bomb that we might conceivably construct on the surface of the earth is a mild fire cracker in comparison with the tremendous explosions of the solar atmosphere. When I say that I have seen some of these explosions with a mushroom cap twice as big as the

earth, you can get some rough idea of the energies. Moreover, the explosions may reach several hundred thousand miles.

DAVIS: But doesn't the energy of the sun itself come from hydrogen? That's the famous theory of Dr. Hans Bethe, now at Cornell.

MENZEL: Oh, yes. The sun and all the stars, for that matter, owe their energy to a process wherein hydrogen is built into helium.

DAVIS: Well, is that process more efficient than the splitting of uranium or plutonium as far as energy production is concerned?

MENZEL: Yes. The hydrogen-helium reaction, if one can make it "go," is the most effective source of energy that we know of in the world today.

DAVIS: Then you think you could make a better bomb out of hydrogen than out of uranium?

MENZEL: The process would release more energy. But we first have to make it "go." How to accomplish this on the earth is beyond my knowledge. But on the sun we have a relatively simple process wherein carbon atoms, deep in the sun's interior, successively capture four hydrogen atoms, digest them in the atomic nucleus, spit out an atom of helium and a lot of energy, finally returning to carbon again. This process, first discovered by Dr. Bethe of Cornell, is called the "carbon cycle." It is what keeps the universe running.

DAVIS: Thank you, Dr. Menzel, for this new look at the sun.

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## Neutrons From Reaction Of Lithium and Hydrogen

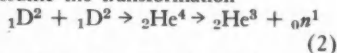
# The First Tritium

Part Two

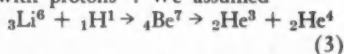
### A Classic of Chemistry

TRANSMUTATION EFFECTS OBSERVED WITH HEAVY HYDROGEN, by M. L. E. Oliphant, P. Harteck and Lord Ruth-  
erford, in *Philosophical Transactions of the Royal Society, London, Vol. A* 144, pp. 692-703, May 1934.

► IN ORDER to account for the production of neutrons of the observed energy and number we have been led to assume the transformation



in which the unstable  ${}_2\text{He}^4$  nucleus first formed breaks up into a helium isotope of mass 3 and a neutron. The assumption of the formation of  ${}_2\text{He}^3$  as a product of such a transformation is not without a precedent, as we have already concluded that it is produced, together with a normal  $\alpha$ -particle, as a result of the bombardment of  ${}_3\text{Li}^6$  with protons<sup>16</sup>. We assumed



and found that the observed ranges of 11.5 and 6.8 mm were in good accord with the application of momentum considerations to this reaction. Dec<sup>17</sup> has obtained very definite evidence that the two short-range particles are emitted in opposite directions, and we have confirmed that it is the  ${}_3\text{Li}^6$  isotope which is concerned in this transformation<sup>18</sup>. It seems quite clear, therefore, that  ${}_2\text{He}^3$  can exist

under these conditions, and from the observed ranges of the particles we are able to calculate its mass in the following way. The longer range of 11.5 mm is reasonably well known and it will correspond with the  ${}_2\text{He}^3$  particle. For the same velocity an  $\alpha$ -particle would go 4/3 times as far because of its greater energy. Hence the velocity of the  ${}_2\text{He}^3$  is the same as the velocity of an  $\alpha$ -particle the range of which is 1.53 cm, corresponding with an energy of  $2.5 \times 10^6$  e-volts. The energy of the  ${}_2\text{He}^3$  will be three-quarters of the energy of this  $\alpha$ -particle, i.e.,  $1.88 \times 10^6$  e-volts. The total energy produced in the transformation is thus  $3.30 \times 10^6$  e-volts, or the corresponding change in mass is 0.0035 units. Hence the mass of the  ${}_2\text{He}^3$  is

$$(6.0145 + 1.0078) -$$

$$(4.0022 + 0.0035) = 3.0166,$$

using Bainbridge's (*loc. cit.*) value for the mass of  $\text{Li}^6$ . On the other hand, we can use the mass 6.0157 calculated from the disintegration of  ${}_3\text{Li}^6$  into two  $\alpha$ -particles of 13.2 cm range under bombardment by dipions<sup>19</sup>, the data for this transformation being extremely good. From this transformation we obtain for  ${}_2\text{He}^3$  a mass of 3.0178 units.

Substitution in reaction (3) of the masses calculated in the above man-

*Italic superscripts refer to literature citations at the end of the article.*

ner leads to the appearance of excess masses of

$$(2.0136 + 2.0136) - (3.0166 + 1.0067) = 0.0039$$

and

$$(2.0136 + 2.0136) - (3.0178 + 1.0067) = 0.0027,$$

respectively, corresponding to energies of  $3.6 \times 10^6$  and  $2.5 \times 10^6$  e-volts. The neutron would receive three-quarters of this energy, i.e.,  $2.7 \times 10^6$ , or  $1.9 \times 10^6$  e-volts. Either of these two values are in good accord with the approximate value of  $2 \times 10^6$  e-volts found from our experiments, but Dee<sup>20</sup> has now obtained expansion chamber photographs of the recoil nuclei, analysis of which suggests that the lower of the two figures is more nearly correct, and that the neutrons emitted at right angles to the bombarding beam of dipions are homogeneous in velocity, as required by our reaction.

The recoiling  ${}^3\text{He}$  nucleus possesses an energy of about  $0.7 \times 10^6$  e-volts, i.e., a range of 5-6 mm as a maximum<sup>21</sup>. The thinnest mica window we have been able to use has a stopping power of 3 mm of air, and the residual range of 2-3 mm is not sufficient for the particle to enter our counting chamber and produce a deflection of appreciable size. We have searched very carefully for such a doubly charged particle, both with a special type of counting chamber of small depth, and by looking for scintillations produced on a screen of zinc sulphide placed inside the apparatus itself and covered with aluminum of 2 mm stopping power to prevent light and scattered dipions from reaching it. In both cases the presence of a

very intense radiation which is strongly absorbed in a fraction of a centimetre of air, gave rise to so much disturbance as to render counting impossible. Thus, while we have not yet detected the  ${}^3\text{He}$  particles which we believe to be present, we have not yet obtained any evidence that they do not exist.

No evidence of the existence of an  ${}^3\text{He}$  isotope has been obtained by ordinary methods, although the possibility of its existence has been suggested at various times. It is not likely that while the new isotope may prove to be unstable over long periods it may yet have a sufficiently long life to be detected by counting methods and in the expansion chamber. We have not detected any after-effects lasting for a few seconds or more, suggesting the expulsion of a positive electron or other charged particle. If the  ${}^3\text{He}$  nucleus is unstable, there are a number of possibilities as to the mode of transformation.

It is evident that the experiments we have described suggest very strongly that the neutrons resulting from the bombardment of dipion with diplogen are homogeneous in velocity, and since large yields are obtainable at comparatively low bombarding potentials they should serve as an almost ideal group for experimental work on the properties of neutrons.

In addition to a study of these transformations, we have made a number of observations on the neutrons, protons, and also  $\alpha$ -particles emitted from lithium, beryllium, carbon, and other elements under dipion bombardment. We hope to give an account of these experiments in a subsequent paper.

In conclusion, we have to express our thanks for help with some of the experiments to Mr. Kempton and Mr. Westcott, and we acknowledge our indebtedness to Mr. G. R. Crowe for his technical assistance throughout. Dr. P. Hartek is indebted to the Rockefeller Foundation for a grant.

### Summary

An account is given of the effects observed when diplons are used to bombard targets of compounds containing heavy hydrogen. It is found that a group of protons of 14.3 cm range is emitted in very large numbers. A shorter 1.6 cm range group of singly charged particles is also observed, and it is shown that the two groups contain equal numbers of particles. A discussion of the reaction which gives rise to them is given, and reasons are advanced for supposing that the short-range group consists of nuclei of a new isotope of hydrogen of mass 3.051. The number of particles emitted has been investigated as a function of the energy of the bombarding diplons, and the absolute yield for a pure diplon beam hitting a pure diplogen target is esti-

mated to be about 1 in  $10^6$  at 100,000 volts.

Neutrons have been observed in large numbers as a result of the same bombardment. It is shown that the energy of the neutrons is about  $2 \times 10^6$  e-volts, and it is suggested that they arise from an alternative mode of breaking up of the unstable form of helium nucleus formed initially by the union of two diplons. This other mode results in the expulsion of a neutron and a helium isotope of mass 3 in directions opposite to one another. If we calculate the mass of  ${}^3\text{He}$  from energy and momentum considerations of the ranges of the short-range groups emitted from  ${}^3\text{Li}^6$  when bombarded by protons, the energy of the neutron can be deduced and agrees well with experiment.

### REFERENCES

- 16—Proc. Roy. Soc. A, vol. 141, p. 259 (1933).
- 17—"Nature" vol. 133, p. 564 (1934).
- 18—"Nature" vol. 133, p. 377 (1934).
- 19—Oliphant, Kinsey and Rutherford, Proc. Roy. Soc. A, vol. 141, p. 722 (1933).
- 20—Not yet published.
- 21—The energy and range of the particle depends to some extent on the direction of emission relative to the bombarding particle, and will be greater in the forward direction.

## Measure Atom's Energy

► MORE ACCURATE measurement of the energy inside an atom can now be made as a result of experiments with the cyclotron at the University of California.

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